WORLD ANIMAL REVIEW

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A QUARTERLY JOURNAL DEVOTED TO WORLD DEVELOPMENTS IN ANIMAL PRODUCTION, ANIMAL HEALTH AND ANIMAL PRODUCTS

World Animal Review

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COVER PHOTOGRAPH: A student being taught how to use a microscope by a state veterinarian at the Agricultural Technical Institute, Kitega, Burundi.

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Twenty years with no progress?

H.A. JASIOROWSKI *

Since the second world war the developed countries have enjoyed a period of prosperity and economic development during which they have substantially increased their animal production. With improved living standards the amount of animal protein in the diet has risen and the demand has gradually shifted from milk and eggs to meat, particularly, in recent years, to beef. In some countries the average daily consumption of animal protein has reached a level of 70 grams per caput.

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Unfortunately, an increase in animal production has not taken place to the same extent in all areas. In some the average daily intake of animal protein per person is as low as 3 to 5 grams. What developments have in fact taken place in animal production during the last 20 years?

Animal productivity

In the highly developed countries the number of animals has increased slightly but the most important progress has been in the increased output per animal due to developments in animal genetics, and improvements in animal nutrition and husbandry techniques. For example, the average annual milk production per dairy cow increased in the United States during 1950-70 from 2 389 to 4 258 kilograms; in France it rose from 1 817 to 3 096 kilograms and in Japan from 2 920 to 4 340 kilograms (FAO, 1972a). Similarly, meat production per animal and eggs per hen increased substantially. But what about the rest of the world?

World figures for total meat and milk production show a definite increase between 1950 and 1970. Table 1 shows that meat production more than doubled, reaching an annual increase of 3.8 percent. The lowest

TABLE 1. World and regional meat production, 1950 and 1970

	1950	1970	Change 1970 over 1950	Average annual increase
	Thousand tons		*1950 = 100*	*Percent*
Europe (including U.S.S.R.)	14 479	35 250	243.4	4.5
North America	13 191	24 745	187.6	3.2
Latin America	6 185	10 183	164.6	2.5
Near East	956	1 999	209.1	3.8
Far East (including China)	7 475	18 789	251.3	4.7
Africa	2 253	3 390	150.5	2.1
Oceania	1 652	3 170	191.9	3.3
WORLD	46 191	97 526	211.1	3.8

TABLE 2. World and regional milk production, 1950 and 1970

	1950	1970	Change 1970 over 1950	Average annual increase
	Thousand tons		*1950 = 100*	*Percent*
Europe (including U.S.S.R.)	132 884	232 776	175.2	2.8
North America	59 403	61 568	103.6	0.2
Latin America	12 608	23 445	186.0	3.2
Near East	7 759	12 307	158.6	2.3
Far East (including China)	29 242	45 225	154.7	2.2
Africa	6 162	9 635	156.4	2.3
Oceania	10 274	13 542	131.8	1.4
WORLD	258 302	398 498	154.2	2.2

rise was in Africa at 2.1 percent per year, and the highest, largely pig and poultry meat, in Asia and the Far East (including China) at 4.7 percent (FAO, 1972a).

Increases in total milk production for the same period are presented in Table 2. The annual world increase was 2.2 percent, with the highest rise in Latin America at 3.2 percent and the lowest in North America at 0.2 percent. However, if only these two tables are considered, one could be misled and come to an optimistic but wrong conclusion on world animal production developments in the last 20 years.

TABLE 3. World and regional average per caput meat and milk production, 1950 and 1970

	Total meat [1]				Total milk	
	1950		1970		1950	1970
	Kilograms					
Europe (including U.S.S.R.)	25.2	(12.3)	50.0	(21.2)	231.1	330.3
North America	79.4	(33.3)	109.0	(49.1)	356.1	271.3
Latin America	38.2	(30.6)	35.9	(26.8)	77.8	82.7
Near East	9.5	(8.6)	11.1	(9.9)	76.9	72.1
Far East (including China)	5.8	(2.3)	9.3	(2.4)	22.6	22.5
Africa	12.0	(10.0)	11.1	(8.9)	32.6	31.5
Oceania	133.6	(119.4)	164.4	(145.8)	830.9	702.2
WORLD	18.5	(9.9)	26.2	(12.3)	103.3	107.0

[1] Figures in brackets refer to beef, veal, mutton and goat meat.

Per caput animal production

Although the annual meat production increase has been 4.7 percent in Asia and the Far East and 4.5 percent in Europe, it should be noted that Asia and the Far East produced only about half as much meat as Europe, while the human population is almost three times as high. It would therefore be better to analyse animal production during the last 20 years by expressing it as "production per caput of human population." It should be remembered that this takes no account of the considerable export trade in meat and milk products from such countries as Argentina, Australia and New Zealand.

Table 3 gives the average meat and milk production per caput of human population in 1950 and 1970 in the various regions. It will be seen that in 1970 the highest production of meat per caput occurred in Oceania, followed by North America and Europe. Unfortunately, it is a completely different picture in the developing regions. In spite of the efforts made by developing countries after independence to accelerate progress in their economy and to raise the standard of living of their peoples, very little has been achieved in the field of animal production.

In Africa and Latin America, meat production per caput has decreased substantially during the last 20 years. In the Near East, meat production per caput remained practically unchanged, and only in Asia and the Far East has it increased appreciably, from 5.8 to 9.3 kilograms per caput. However, the importance of this increase diminishes when it is realized just how low this production really is. What is of significance is the fact that the proportion of meat production from ruminants (cattle, buffalo, sheep and goats) dropped more than total meat production, due mainly to the preference of the east Asian for pig and poultry meat.

The table gives similarly disturbing figures for milk production. A per caput increase in the last 20 years occurred only in Europe and Latin America. Declines in North America and Oceania were deliberate due to troubles with world surpluses of dairy products. In the developing regions, however, little or no progress in milk production per caput took place during the 20-year period. In Africa, the Far East and the Near East, per caput production declined from the already low 1950 figures. In Latin America, there was a small but not very significant increase.

How disappointing these per caput production figures are can be illustrated by the following comparisons. In 1950, Europe (including the U.S.S.R.) produced 4.3 times as much meat per caput as Asia and the Far East, 2.7 times as much as the Near East and 2.1 times as much as Africa. In 1970 these figures were respectively 5.4, 4.5 and 4.5. Whereas in 1950 Latin America produced 1.5 times as much meat per caput as Europe, this ratio in 1970 was only 0.7

Similar drastic figures can be presented for milk. As an example, about 10 times as much milk per caput was produced in Europe in 1950 as in the Far East; in 1970 this ratio had become 15.

There is not the slightest doubt that in the field of animal production another — and growing — gap can be observed between the rich and the poor countries.

Agricultural production

It seems to be relevant here to compare the progress of livestock production in the developing countries during the last two decades with the development of other branches of agricultural production.

In the developing countries as a whole, total agricultural production expanded over the past 15 years or so (1952-54 to 1967-69) at an average annual rate of 2.9 percent (FAO, 1970b). During a similar period fisheries output grew by 9 percent per year in the developing countries, and the annual output of high-value

TABLE 4. Annual average increases in human and animal populations, 1950 to 1970

	Human population	Cattle and buffalo	Sheep and goats	Pigs
	Percent			
Europe (including U.S.S.R.)	1.0	1.7	0.8	3.8
North America	1.6	1.7	—0.4	—0.05
Latin America	2.8	2.1	0.4	3.8
Near East	2.7	2.7	2.1	3.5
Far East (including China)	2.2	1.3	2.6	5.3
Africa	2.4	1.9	1.4	2.1
Oceania	2.3	2.4	2.5	2.8
WORLD	2.0	1.7	1.5	3.8

forest products increased even more: plywood by 9 percent, pulp by 16 percent and newsprint by 18 percent. In the developing regions per caput agricultural production grew by only 0.3 percent per annum (zero in Latin America and only 0.1 percent in Africa) and per caput food production also grew by 0.3 percent (in Africa it decreased, minus 0.3 percent).

The total increase in cereal production was partly due to an expansion in the area of arable land; for example, the area under cereals has been increased during the last 20 years in South America by 70 percent, in Asia and the Far East by 30 percent, and in Africa by 40 percent. At the same time the yield per hectare has grown thanks to the green revolution: average wheat yields in Asia and the Far East increased from 820 to 1 170 kilograms per hectare, in Africa from 700 to 1 010 kilograms, and in South America from 1 070 to 1 310. However, during this same period, wheat yields in Europe jumped from 1 470 to 2 850 kilograms per hectare (almost a 95 percent increase).

This means that the overall picture of stagnation in agricultural production in the developing countries is very similar to that in the field of animal production, although progress in cereal output has been more pronounced.

TABLE 5. Average production per animal 1950[1] and 1970

	Beef/veal		Mutton/ goat meat		Pork		Milk from cattle/buffalo		Milk from sheep/goats	
	1950	1970	1950	1970	1950	1970	1950	1970	1950	1970
	Kilograms									
Europe (including U.S.S.R.)	37.7	59.7	5.0	6.6	70.3	80.1	804.0	1 034.8	29.5	18.1
North America	59.1	87.7	8.4	11.1	83.4	106.0	671.2	495.7	—	—
Latin America	28.5	29.4	2.7	2.7	20.5	17.6	77.8	95.0	1.5	2.1
Near East	13.8	17.3	3.6	4.4	80.0	95.0	173.1	177.5	22.5	20.2
Far East (including China)	6.5	8.2	3.9	4.0	33.4	38.6	82.2	97.5	6.8	6.1
Africa	13.9	13.6	3.1	3.5	34.1	41.1	50.9	57.6	7.2	6.6
Oceania	41.6	45.8	4.5	5.7	67.4	66.7	521.5	431.3	—	—
WORLD	23.0	31.2	4.0	4.7	53.1	54.6	276.5	308.4	11.9	8.9

[1] Average 1947/48-1951/52.

Reasons for stagnation

Table 4 shows the average annual increase in human population and number of animals from 1950 to 1970 in the different regions. In general, the increase in livestock numbers follows the increase in human population. But is the total growth of meat and milk production in the different regions due to an increase in livestock numbers?

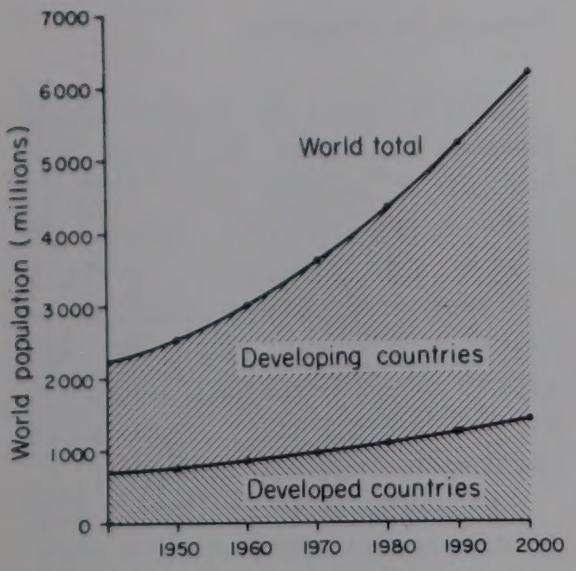
The figures given in Table 5 help to answer this question; they show the average production per animal in 1950 and 1970 in the different regions. It can be seen, from a purely technical point of view, that the stagnation of per caput production of meat and milk in developing countries is associated with low animal productivity, and what increase there has been in these countries in the last 20 years has been mainly due to the increase in the number of animals. In the developed countries average production per animal grew substantially during this period, with the exception of milk production in North America and Australia due to a change in the proportion of dairy cows in total cattle populations.

As far as the developing countries are concerned, beef production per head of cattle and buffalo increased a little in all regions except Africa, where it actually declined slightly. Meat production per sheep and goat remained almost unchanged but there were general increases in pig productivity, except in Latin America. Milk production per head of cattle and buffalo increased but that of sheep and goats declined.

The seriousness of the overall lack of sufficient progress in meat and milk production per animal in the developing regions can be understood only when it is realized just how low this production had been in 1950.

Although some increase in total meat and milk production has been achieved in developing countries dur-

FIGURE 1. The world population estimates to the year 2 000 show that a continually increasing proportion of people will be in the developing countries.



ing the last two decades, this was due mainly to increased numbers of animals, largely made possible by successful animal health campaigns. This, however, is not the best way of increasing production. With very low animal productivity it means comparatively expensive output because much of the feed input goes into maintenance and only a small part into real production. Furthermore, since ruminating animals depend mainly on natural local feed resources in the developing countries, there are rather limited possibilities for expansion in numbers unless there is to be serious overgrazing. On the other hand, an increase in the number of pigs and poultry calls for higher feedgrain inputs, possible on a large scale in developing countries only if such feeds are available.

The lack of progress in animal production is not only the result of lack of technical inputs and resources but also the consequence of the slow economic development of the developing countries. Gross domestic product (GDP) per caput has increased only slightly in these countries and the subsistence form of agricultural production still predominates. The marketing of animal products is still in its initial stages. There are, of course, a few positive exceptions and some countries have managed to achieve a faster rate of development than others, but the general picture of stagnation in animal production in developing regions remains the same.

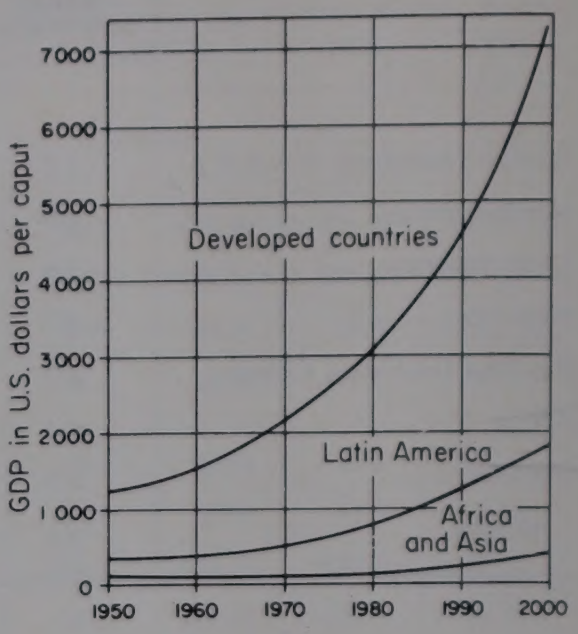
The future

In its study *Provisional Indicative World Plan for Agricultural Development* (FAO, 1970a), FAO pointed out that the livestock production growth in the 1962-85 period in developing countries would be substantially slower than the growth in demand for animal products. The study envisaged an average meat production growth of 3.2 percent and a demand of 4.2 percent, and for milk production an annual growth of 2.9 percent and a demand of 4.6 percent. In Figure 1 the increase in human population up to the year 2000 is presented. It is the well-known figure, but is worth presenting again to show the magnitude of the problem.

In Figure 2 the growth of GDP per caput in different regions up to the year 2000 is presented (Ward *et al.*, eds., 1971). If the projections of both these figures are right, the people in the developing countries will not have enough purchasing power to influence the local market to create an increase in animal production.

Table 6 (Witze, 1971) gives projections for 1980 and 2000 agricultural population and production in developed and developing countries.

FIGURE 2. The ever widening gap in GDP per person in the developed and developing regions of the world.



SOURCE: Ward *et al.*, eds., 1971.

Per caput production figures in 2000 are expected to be $3 720 and $91 in developed and developing countries respectively — 40 times greater in developed countries. The majority of people in developing countries will still not be able to buy from the increasing meat supplies. In some countries there is a substantial middle class in the cities which can contribute to the development of animal production, provided that prices are established which would give enough incentive to producers. At the same time some kind of market control should allow the producers, as well as those responsible for slaughtering, processing and distribution, to get a fair share of final retail prices. This way there are

TABLE 6. Projections of agricultural population and production in developed and developing countries, 1980 and 2000

	1980		2000	
	Developed	Developing	Developed	Developing
	Millions			
Agricultural population . . .	75	1 230	50	1 480
	Million U.S. dollars			
Agricultural production . . .	125 000	77 000	186 000	135 000
	U.S. dollars			
Per caput production of agricultural population	1 660	63	3 720	91

SOURCE: Witze, 1971.

possibilities of increasing production for the local market and of keeping the retail price as low as possible.

Agricultural prices

The developing countries are conscious of this situation, which affects not only animal but all agricultural production. It is the main reason they claim more access to the markets of the developed world. For the same reason the Director-General of FAO asked for a study on world agricultural adjustments. This study (FAO, 1972b) recommends that rich countries should adjust their agricultural production to make it possible for developing countries to export agricultural products to their markets. As far as animal production is concerned, the developing countries have a big chance to develop exports of beef, and also some mutton, to world markets. A recent FAO study (FAO, 1972c) showed that by 1980 the annual deficit of beef in western Europe will reach about 1 million tons. This deficit will also grow in such countries as the United States and Japan, and other smaller countries. This world shortage — and the high prices involved — should stimulate developing countries to improve their beef production, as they have about 70 percent of the world population of cattle and buffalo.

Such statements are sometimes criticized because it is argued that the developing countries should not be encouraged to export food products which they need so badly in their own countries. It is true that meat consumption in the developing countries is very low; it is also true that even if production were increased in these countries only a small number of people would be able to buy meat. The moral argument against export of foodstuffs from developing countries, especially those countries which have some malnutrition, is fully understood. However, from the point of view of the long-term social policy, benefits can be expected since beef production for export will help to accelerate overall development. If this is true it should become the main target of those developing countries which have potential animal resources; and it should also be considered a priority for international assistance.

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The author has presented the case of the very slow progress of animal production in the developing countries. This is a subject which many governments and international organizations consider to be of primary importance — nutritionally, technically, economically, socially. We invite the readers of *World Animal Review* to send us their views on this subject, of significance to all countries in developed and developing regions.
Letters should be addressed to:

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FUTURE ISSUES OF "WORLD ANIMAL REVIEW"

Articles in future issues will include:

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G.M. Ward (United States)

A model for improved milk production in India
D. Sundaresan (India)

Milk production in Brazil
J.M. Hall (FAO)

Control measures against contagious bovine pleuropneumonia in Ivory Coast
E.P. Lindley (FAO)

African animal trypanosomiasis control
P. Finelle (FAO)

Feeding citrus by-products
B. Gohl (Sweden)

Dairy equipment for developing countries
J. Marque (FAO)

Other subjects which will be featured include:

Performance testing of dairy and beef cattle

Camels for meat and transport

Yaks and chauris

Feeding and management of donkeys

Bali cattle

Milk production in Israel

East Coast fever

Manpower planning for the animal industries

Housing of pigs in the tropics

International lending for livestock development

P.J. BRUMBY *

Lending by international organizations and governments in the agricultural sector has increased greatly in the last few years and now amounts to about U.S.$630 million annually. Of this total about $240 million are at present provided by the World Bank. The other major sources are the regional development banks of Latin America, Asia and Africa, and direct bilateral lending by governments. Lending to the livestock sector now accounts for about 20 percent of the total, or $120 million per year.

The basic function of the World Bank and the regional banks is lending for development projects, and they are naturally particular about the careful selection, formulation and appraisal of the projects they finance. As the statutes of these banks direct them to plan their lending so as to make a maximum contribution to the growth of the economy of the borrowing country, a detailed analysis of the major sectors of that economy is the first stage in the lending process, the objective being to assess and quantify sectorial priorities and investment needs. Based on this sectorial analysis, the identification of desirable investment projects follows.

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Beef development

The extremely good market prospects for beef that have been apparent throughout the last decade have been an important factor in stimulating lending in the livestock sector. Many of the early livestock loans were directed to beef cattle development in South America where extensive grassland areas and large management units provided relatively simple conditions in which to test and develop the new venture of international lending for livestock development. Recent livestock projects have been directed to more complex situations where small mixed-farming practices and a more limited local knowledge of livestock production problems have been frequent constraints to local investment.

High-yielding varieties

Of the immense scope for increased livestock development, little needs to be said here. The international market outlook for beef could hardly be more favourable, while the rapid decline in dairy surpluses has led to a situation in which the now high costs of imported skim milk powder and butter oil have completely changed the dairy production outlook in many tropical countries. The advent of high-yielding crop varieties and multiple cropping has also had a profound impact on livestock investment needs. The greater availability of foodgrains, particularly in south Asia, makes diversification to livestock production more attractive in the national plans of previously grain-deficit countries. Increased yields per unit area enable other crops or livestock products to be grown, while increased grain yields also imply increased crop residues and grain by-products suited to livestock feeding. The greater use of multiple cropping associated with expanded irrigation and drainage projects often involves critical planting and harvesting dates that can only be attained if sufficient draught power, usually bullocks of good size and quality, are available. It is primarily for this reason that several Asian countries are now pushing ahead with cattle improvement plans.

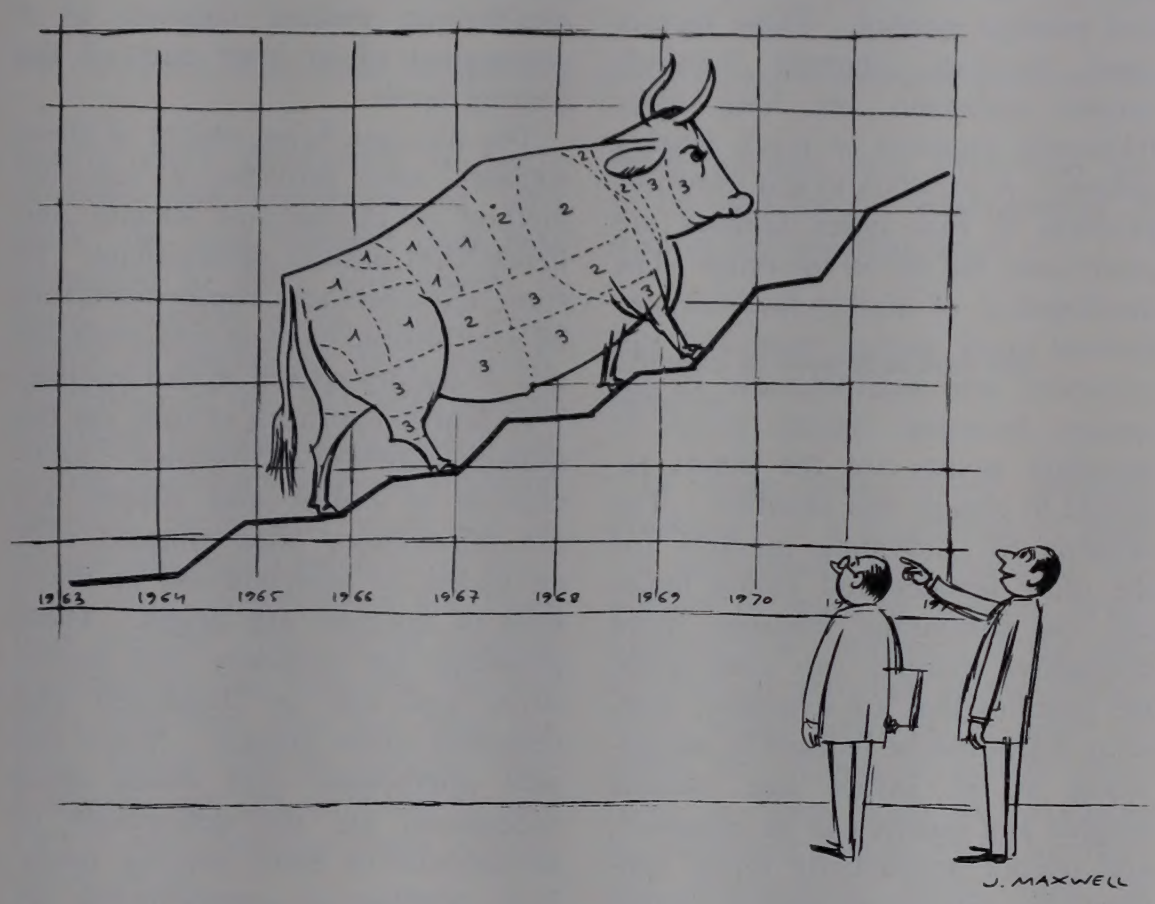
Possibilities for livestock development

That very large increases in livestock productivity are technically feasible is beyond question. In many parts of Africa more than 50 cows

are required to produce a ton of meat each year; in Europe the comparable figure is 10 cows. Large areas remain to be developed for more intensive pastoral purposes: the central lowlands of South America, the Campo Cerrado of Brazil, the grasslands of central Africa and the highlands of many southeast Asian countries, for example, where the grazing of planted pastures provides the basic technique required for more intensive agricultural settlement in the years to come. The eradication of the tsetse fly in Africa would open up much land at present unsuitable for cattle; and the integration of livestock and legume pastures into the traditional arable cropping of much of the Near East and Mediterranean areas would benefit both crop yields and livestock output.

Many problems must be solved before these land resources can be used effectively, but the important point at this stage is to appreciate that these resources exist, and that given the necessary imputs they can become much more productive.

As with general agricultural projects, the nature of livestock projects being financed by the international banks is steadily widening. Most early projects involved the extension of on-farm credit and technical assistance to private sheep and beef cattle operations in the temperate zones. Recent projects have increasingly involved tropical beef areas, together with dairy, pig and poultry farming. Mixed agricultural and livestock enterprises, particularly in small farm operations, are now an important outlet for bank funds together with agro-industries involving slaughterhouses and milk-processing and meat-packing plants. Group, cooperative and state-owned ranches have also been financed where traditional social structures indicated these were desirable forms of livestock operations and the most efficient means of utilizing credit. The essential elements of these various types of projects are common ones. They include improved management, the transfer of appropriate technology, the training of local staff, the strengthening of local administering organizations and the application of sound economic and financial lending policies by credit institutions.



The extremely good market prospects for beef that have been apparent throughout the last decade . . .

International loans

The approach of the FAO Investment Centre to livestock development requests by Member Governments endeavours to be as pragmatic as possible. Both imagination and flexibility are required to cope with varying requests, as there are enormous differences between countries in their soils, climate, customs, tradition and the acceptance of new technologies. A usual practice, following a request for development financing in the livestock sector, together with an indication of interest in the project from a banking group, is to send an identification mission from the Investment Centre to formulate a project suited to local circumstances, and to make an assessment of its likely size and scope. Detailed preparation studies follow, often made by national groups formed for the purpose, or by consultants supervised by the Investment Centre. The detailed project feasibility study that results then goes to the interested bank for evaluation and appraisal before a loan is granted.

To pass the strict appraisal standards of the World Bank and the regional banks, a project proposal must meet the criteria of priority in the economy as a whole as well as within the livestock sector, taking into consideration problems of organization and management and including the availability of technical staff and other supporting services. The economic climate in the country must be conducive to increased production and, for this purpose, it is sometimes necessary to make a loan conditional on the government's instituting policies likely to increase incentives to the livestock producer. Part of the loan funds may also be directed to financing special studies on marketing or technical problems directly related to the successful outcome of the first or subsequent stages of a project. Such project-

related operational research, with the services of experienced technical directors for each project, fills the gap of often ineffective extension services and permits the initiation of viable projects in areas and with farmers previously considered as unlikely credit subjects by commercial lending institutions.

Past requests for the external financing of livestock development have concentrated heavily on the beef cattle sector, which has the greatest demand for large quantities of long-term development capital. The pig and poultry industries usually require little support from public sector credit as the time lapse between investment and returns in these subsectors is comparatively short, and their relatively high output per unit of capital used reduces the need for long-term financing. In addition, these industries are frequently directly competitive for human foodgrains. In grain-deficient countries care must therefore be taken in encouraging their expansion.

International support for dairy investment has been impeded by the stockpile of European dairy surpluses at subsidized export prices, a situation which has recently changed completely. In consequence, a rapidly expanding demand for financial and technical assistance in the dairy sector is now foreseen.

The four concepts

The technical philosophy of cattle development — if it can be called that — which has evolved in the FAO Investment Centre livestock group as a result of preparing many investment projects revolves around several concepts, the importance of which obviously varies from project to project.

The first of these concerns the improvements in production that simple changes in management can achieve. Weaning calves, separating heifers from the herd, seasonal mating, saving feed for the dry season, separating pregnant and dry cows, favouring the young female cattle in drought periods, and vaccinating and dipping against the more prevalent disease and parasite problems can achieve quite dramatic increases in livestock productivity. In consequence, much external lending has been used to provide the simple physical inputs such as fences, water points, dips and corrals, and disease control, that improved cattle management requires.

The second approach involves changing herd structure. In many seminomadic and extensive livestock breeding areas, male animals are sold at an advanced age. The reasons for this are several and include the use of livestock as a financial asset and prestige symbol. These factors apart, however, younger livestock cannot withstand the long treks frequently required to reach market centres. A corollary to this transport problem is that older females are rarely sold, but die on the range. The development of market facilities, organized stock routes, road and rail transport, and semi-intensive or intensive fattening centres close to slaughter points are the inputs required to change this situation. The rewards for providing markets for the older females and young males can be substantial because more productive animals can then graze the pastures that are available, mortality losses can be reduced by slaughtering at an earlier age, carcass weights and quality can be increased, and overall productivity raised substantially, without necessarily changing existing birth or mortality rates or herd or flock management systems. In this context, intensive fattening systems can provide a valuable economic return to the industry as a whole, even when the financial returns of these fattening systems may be marginal.

Thirdly, seasonal fluctuations in the availability of pasture characterize almost all pastoral areas and alternating feast and famine situations provide the common nutritional regime of most grazing animals. During the dry season abundant dry standing feed is often available, but its use is limited by its distance from water and by its low protein level, which effectively reduce the amount of this dry feed an animal will consume. The end result is that the majority of cows with a calf at foot receive insufficient feed for both lactation and reproduction. As a consequence they calve every second year rather than annually. Herd productivity is depressed both by the lower calving rates of breeding cows and the see-saw pattern in the growth of animals. Strategic placing of extra dry-season water points, coupled with increased protein intake in the dry season, are practical ways of mitigating this problem. Probably the best, cheapest and often the only practical way of providing additional protein is by establishing pasture legumes as a component of at least part of the grazing lands.

The nitrogen-fixing ability of these legumes also provides a low-cost method of raising soil fertility and hence total pasture productivity. In some circumstances supplementation by a cottonseed cake or urea-molasses mix in the dry season is also feasible.

A fourth approach centres on the mineral nutrition of livestock. Deficiencies of cobalt and copper are not uncommon, often coupled with an excess of molybdenum in many soils of volcanic ash origin. These problems are relatively well understood and can be diagnosed and remedied quite quickly. Much less well appreciated and much more widespread are the deficiencies of phosphorus in many grazing lands. This problem is compounded by the limited capacity of many tropical grasses to absorb phosphorus and to provide it in adequate quantity to grazing animals. The use of boneflour supplements and, better, of phosphatic fertilizers coupled with the planting of tropical legume-based pastures, are possible solutions, and the latter requires the development of much cheaper sources of phosphatic fertilizer.

Importance of exotic cattle

The importation of specialized beef and dairy cattle is a frequent component of requests for international livestock loans. As in-

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tensive dairy production is rarely possible with indigenous or zebu cattle, the most frequent immediate constraint to dairy development in many countries is the limited availability of specialized dairy animals. The choice of the right dairy animals for local feeding, management and pricing conditions is always a difficult decision, particularly when the logistical and health problems of large-scale cattle importations are taken into account. The use of artificial insemination can help but the first cross with local zebu and dairy animals retains difficult milking characteristics and can normally be used only in semi-intensive stages of dairy development.

European dairy cattle, however, are much less tolerant of poor nutritional and climatic conditions and many past importations have been largely wasted, either through inadequacies in local management or by a lack of incentives to rear their progeny. This latter situation occurs commonly where credit is freely available for purchasing imported animals and where rearing costs for calves are high. Artificial insemination in range beef cattle is only practical in very limited circumstances; but as bulls of special beef breeds can generate rapid genetic changes in local cattle the importation needs of a beef cattle industry are usually small. The importation of beef-breeding cows is normally justified only when they are to be used for the establishment of nucleus bull-breeding herds.

Changes in crop practices and varieties

In those areas where livestock production is a by-product of peasant agriculture, it is obviously important to think of livestock development as a component of the total agricultural activities of the farmer. Thus, where high-yielding grain varieties are introduced, greater quantities of fallen grain are available to scavenging animals whose numbers and productivity might then be increased, particularly if the type and availability of feed to be scavenged in the more critical feed periods of the year are known. Regrettably, however, such an obvious and important field of applied animal nutrition has been overlooked by virtually all research workers. High-yielding varieties of wheat and rice produce grain:straw ratios markedly different from those of traditional varieties; and although grain yields may be increased the associated straw for animal feeding may be in even shorter supply than before. Changes in the feed value of this straw, associated with changing dry-matter content of the grain, is another field largely unexplored by livestock nutritionists.

Critical planting dates associated with multiple cropping in intensified land-use projects frequently require the use of better agricultural implements which, in turn, often necessitate bigger and better bullocks to pull them — animals which can only come from well-planned and implemented schemes for the better breeding, feeding and management of the frequently stunted, starved and otherwise impoverished local cattle. Multiple-cropping projects may also lead to seasonal surpluses of crop residues suitable for strategic fattening operations, provided an organizational unit to move "stores" and "fattened" animals exists, while the greater use of agricultural by-products such as molasses, maize germ, cottonseed cake and rice bran can provide an excellent opportunity for increasing livestock production with a small investment.

Preparation of development plans

Bank lending for livestock development usually takes the form of a supervised agricultural credit operation. The preparation of a livestock project, therefore, involves an analysis of the institutional framework for credit in the borrowing country and the definition, and perhaps even creation, of an appropriate channel for the lending operation.

This operation is normally supervised by a technical director who provides assistance in the preparation of individual farm development plans. Participating credit institutions usually bear the full credit risk and concern themselves basically with the creditworthiness of sub-borrowers.

One of the most effective practices of bank-supported projects has been the intensive technical assistance in the preparation of the individual farm development plan. Each farm plan sets out in detail the actual inputs to be financed, makes a budget of expected costs and returns, and shows the ability of the sub-borrower to service his loan. Follow-up visits to each sub-borrower are made by the technical staff of the project to assess progress, measure impact and resolve problems. In this manner credit is used as the catalyst in effecting technological and managerial changes, and as a mechanism for transforming advice into action.

Extent of investments

International bank investment in livestock projects now totals close to $1 000 million and it may reasonably be asked what impact these funds will have on meat production and export supplies. In quantitative terms, it requires very roughly a capital investment of some $3 000 to produce an additional ton of carcass beef each year. Thus the $1 000 million already invested are likely to produce an incremental 330 000 tons of beef per year. This is about 0.3 percent of current world production of beef and veal, and about 7 percent of current world trade in beef and veal, figures which suggest that the direct impact of international lending is marginal.

The overall impact of such lending extends, however, well beyond the capital transfer involved. By introducing or extending better technologies and by improving and strengthening national institutions, well-designed projects can lead not only to increased farm production, but also to improved government-developed policies. It follows that justification for international investment in livestock development projects largely relies on the catalytic and qualitative impact such projects can have on local investment rather than in providing a primary and quantitatively important source of investment capital. The design and careful implementation of livestock development projects to be supported by international bank funds therefore assume an importance far beyond the immediate production impact. This importance underlies the great care with which these banks endeavour to design and implement their lending to projects.

Part of total project costs will also be financed by the farmers and credit institutions involved. This is insisted upon in order to ensure real local interest in the success of the project.

Future trends in lending

The World Bank is expected to remain the main external source of financing to agriculture. Its contribution is likely to be about 4 to 5 percent of the total (national and international) agricultural investment required to produce the necessary increases in agricultural production. The direction of international lending provided by the World Bank, as well as its regional counterparts, is subject to change and reflects progress in resolving both technical and socioeconomic problems concerning the role of agriculture and livestock in overall development.

In the livestock sector likely lending trends appear to involve an extension of dairy farming, particularly in smallholder development schemes based on mixed livestock and arable farming, an expansion of livestock marketing, transportation and processing projects, an expansion of applied research projects directed to specific production objectives, and a very much greater emphasis on tropical pasture development and fertilizer use.

In conceiving and preparing such projects to the point where they are suited to international bank financing, hardheaded realism must be the guide. Bouts of euphoria alternating with pessimism caused by many practical difficulties are hazards to be avoided. The challenge to professional capacities in the fields of technology, marketing and investment is immense, and this challenge is essentially one of combining the skills involved in modern livestock technology with the capital resources of international banks in order to make more effective use of land and animals.

Credit is used as the catalyst. . . and as a mechanism for transforming advice into action.

Trends in beef cattle production in the United States

JOSEPH EDWARDS *

Beef production is perhaps the most dynamic sector of the agricultural economy in the United States at the present time, thanks to a consumer demand for red meat that appears to be almost insatiable. This is the result of increasing population and purchasing power, and the effect is to be seen in a number of significant trends in production, including shifts in geographical locations and systems of feeding and breeding. Growth projections for the industry's development foresee continuing expansion at home as well as the need to increase imports of beef above their present levels. There are therefore brighter prospects for developing countries with an export potential since, besides the booming United States market, there is the already considerable European market with increasing import needs.

The United States human population and beef cattle numbers for 1960, 1970, and projected for 1980, are given in Table 1.

In the past decade population increased by 11.5 percent and cattle numbers by 42 percent. Over the same period annual beef consumption increased by 25 percent, to more than 50 kilograms per caput. In the current decade population is expected to increase by a further 16 percent and this, together with still higher consumption, may create a demand 40 percent above 1970 levels.

TABLE 1. United States human and beef cattle populations

	Human population	Beef cattle [1]
	.... *Thousands*	
1960	179 000	26 250
1970	200 000	37 000
1980	232 000	47 500

[1] Cows and heifers over two years old.

The import situation

Imports of beef into the United States consist of live feeder cattle from Canada and Mexico, numbering about 1 million annually, and imports of fresh, chilled and frozen meat (almost all beef), amounting at present to approximately 500 000 tons. Combined, these imports account for about 10 percent of United States domestic consumption. Levels of imports (of carcass meats) are controlled by the Meat Import Act of 1964 which has proved to be less restrictive than exporters had feared. The initial quota intervention or base line quantity of 329 000 tons (the average of 1959-63 imports) has been raised steadily to its present level. Adjustments are made according to domestic production in relation to demand which, as mentioned, is expected to continue to increase.

The national dairy herd

In many countries the national dairy herd is a major, if not the sole, contributor to beef supplies, but in this respect the United States situation is paradoxical. The numbers of dairy cows in production have fallen from a peak of 28 million in 1945 to fewer than 13 million at present, and although the loss in "cow beef" can be estimated, the deficiency in "dairy steer beef" is less easy to evaluate. For a long time calves were slaughtered for young veal and it is only recently

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that they have come to be appreciated as an important source of beef supplies. Therefore, in spite of drastically reduced cow numbers, there is a sizable reservoir of calves to draw upon from a source not previously taken into account.

TABLE 2. Beef-producing states of the United States

Newer breeding states	Cow numbers 1970	Increase since 1955	Traditional breeding states	Cow numbers 1970	Increase since 1955
	Thousands	*Percent*		*Thousands*	*Percent*
Kentucky . . .	1 087	+211	Montana . .	1 570	+39
Mississippi . . .	1 285	+109	Colorado . .	1 100	+57
Tennessee . . .	948	+197	Nevada . . .	343	+ 7
Georgia	856	+128	Arizona . . .	344	—15

REGIONAL SHIFTS IN PRODUCTION

The striking nature of the expansion of the United States beef industry is matched by equally striking changes in the centres of production. The mountain states, embracing the wide open cattle country of the west where, in the late nineteenth century, vast cattle empires were created by unusual alliances of local entrepreneurs and Wall Street financiers, are losing ground to the states of the southeast. Over the past 15 years, the numbers of beef-breeding cows have doubled or trebled in the latter, whereas in the west much smaller increases, well below the national average, have occurred. Mississippi and Kentucky have now to be ranked with Montana and Colorado as substantial beef-breeding states, and the calf production of Tennessee and Georgia greatly surpasses that of Nevada and Arizona (see Table 2).

INTENSIFICATION

Much of the expanding production is at the expense of less profitable enterprises such as cotton and tobacco, but it is also a fact that the area,

FIGURE 1. A herd of breeding beef cattle grazing in a mountain pasture.

PHOTO: COLORADO STATE UNIVERSITY

with much good soil and a plentiful supply of water, is capable of growing good crops for stock and improved pastures which are essential nowadays in the intensification of livestock production. By contrast, the mountain states and their extensive methods are subject to pressures of many kinds. Land values have increased so steeply that the owner of a medium-sized ranch cannot afford to increase his acreage as his costs go up and his income goes down. Sportsmen and hunters compete with him for leases of land in the public domain and corporate developers pay high prices, impossible for ranchers, to meet the new land rush for recreation and retirement living created by urban growth and the overpopulation of cities. Ranch costs, such as wages, fencing and mesquite control, are increasingly difficult to meet at stocking rates of 1 cow to every 50 to 100 acres, and low rainfall and droughts lasting for long periods may reduce not only the supply of range pastures but also the volume of water needed to maintain irrigation systems for growing supplementary feed.

Early weaning

Ranchers are exploring ways to relieve some of these pressures in order to increase the size of the all-important calf crop. A promising system, based on early weaning, has been tried in southern Texas. In place of the conventional weaning at 6 to 7 months, the calves — male and female — were removed at 2 to 3 months of age and transferred to a feedlot. Steers were fattened to finish and to be slaughtered at 12 to 15 months. The heifers went from the feedlot, at about the same age, to good pastures where they were mated to calve at 2 years of age. Feedlot costs were 17 cents per pound (37 cents per kilogram) of live-weight gain and were entirely economic for both steer production and for heifers which calved one year earlier than when reared entirely on the range. The fertility of the herd and the calf crop was increased, the cows, and especially the heifers after their first calving, benefiting from the longer rest. Moreover, in the ranchers' opinion, there was the prospect of a 50 percent increase in cow-carrying capacity as a result of removing steers completely, and heifers for a year, from ranch pastures.

There are cattle areas in the developing world where such a system might bring about rapid increases

FIGURE 2. High-quality beef cows on good arid rangeland.

PHOTO: COLORADO STATE UNIVERSITY

in beef supplies, for example in east Africa, where drought at weaning time destroys a large proportion of the calf crop, especially under semi-nomadic conditions; early weaning and the collection and transport of calves to feedlot centres could result in a substantial increase in off-takes.

Feedlots

Much that has been written about cattle feedlots in the United States might lead the visitor to expect to find most of them in the giant category. Certainly some are of enormous capacity — carrying up to 100 000 or 150 000 cattle — and there is certainly a vast investment in cattle and feed at any one time. Yet it was not until 1969 that the numbers of cattle finished in the larger commercial feedlots (with a capacity of 1 000 cattle or more) came to exceed numbers finished in much smaller feedlots, mainly on farms, with an average annual throughput of 60 beasts (see Table 3).

The large feedlot flourishes where there is good soil, drainage, some shelter and a dry climate with low humidity which allows feeding in the open all the year round. Nevertheless, the "environment" age would seem to cast shadows over very large-scale operations because a number of the problems they create are still unsolved. Animal scientists at Colorado State University regard as a major challenge facing them, and engineers and microbiologists, "the finding of ways to dispose of mountains of animal waste and the prevention of air and water pollution."

Table 3. Annual figures for cattle in feedlots in the United States

Feedlot capacity	Number of feedlots	Number of cattle marketed	Average per feedlot
		Thousands	
Under 1 000	190 783	11 480	60
Over 1 000	2 006	12 326	6 007

Breeds and breeding for beef

The ebullient state of the United States beef market causes repercussions at many levels and nowhere more than on the breeding scene where, at the present time, the desire to experiment with new breeds, hybrids and new breeding systems can only be described as hectic. This can be attributed to many causes among which are a sound backlog of research, now coming into its own, a disenchantment, for real or imagined reasons, with the traditional breeds and a change in public taste toward lean meat and away from fat. Of course records of growth and fertility, and costs of production, are today much more in evidence and available for comparative breed studies, and jet-age travel assists the speed of change. Ranchers may visit Europe overnight to see breeds unknown to them and plan, if they like them, for trial shipments of semen and live cattle. The phenomenon is referred to as an "exotics explosion," the description exotic having simply its original meaning of "imported from abroad."

First it was the turn of the French breeds, with the Charolais already well settled in Mexico and now almost a United States "establishment" breed. More recently other French breeds including the Limousin and Maine Anjou have been imported as well as breeds from the Federal Republic of Germany, the Netherlands, Switzerland and Italy. New British exotics on trial include the South Devon, Welsh Black, Lincoln Red and North Devon. The list of breeds and countries yet to be looked into is by no means exhausted and the great variety and scope for genetic exploration that exist are in striking contrast with the world of dairy cattle breeding in which a single breed predominates.

Figure 3. Part of a large beef cattle feedlot in Texas.
PHOTO: U.S. FEED GRAINS COUNCIL

Traditional breeds will persist for a long time

It is too early to predict the effect of what is happening on the traditional breeds, the prospect for some of the new ones establishing themselves successfully, or the possibility of new combinations of breeds being created and fixed. Nevertheless, observations made during an extensive five-month tour in the United States lead one to hazard a few guesses, the first of which is

FIGURE 4. A corner of a beef cattle feedlot in Canada.

that the traditional breeds — the Hereford and Angus — will persist for a long time. They are the backbone of the national beef-breeding herd and exist on the commercial ranches of the country literally in millions. The relative breed positions, for purebred cattle, may be seen in the numbers of calves registered in 1970:

Hereford:	397 000	
Angus:	352 000	
Charolais:	45 000	
Shorthorn:	36 000	
Santa Gertrudis:	19 000	(classified)
Brahmin:	15 000	

Exotics do not yet feature in the list because the numbers of calvings are so small. The persistence of the Hereford and Angus will not preclude gains from hybrid breeding and here the cross between the two breeds will predominate (as a range cow) except in the south where the Brahmin is used on both breeds with excellent results. It is also possible that the Hereford may absorb — or merge with — two newcomers, the Simmenthal and Maine Anjou, for the crosses are colour marked in the distinctive Hereford way and are often indistinguishable from the purebred Hereford.

SPECIALIZATION ON STRAINS

Experience shows that the Angus and Charolais breeds combine very satisfactorily although whether a new breed will emerge from this or from any other new combination of breeds is open to question. With so much in the melting pot genetically, and with technical advances that seem possible in artificial insemination, oestrus synchronization and twinning by transfer of ova, that are all capable of major impacts in the beef industry, it is much more likely that specialization on strains will come about. In these, hybrid vigour will continue to be exploited in both sexes — in the female, for fertility, ease of calving, milk production and longevity and, in the male, for efficient growth and muscle development. The production of breeding females could therefore become an enterprise quite separate from the production of sires, the ultimate for the latter being the purebred or hybrid "terminal" sire bred entirely from production records in depth, and thoroughly progeny tested. Hybrid cow production is a job for the rancher and many are already engaged in it. The production of terminal sires may require greater scope and backing, and this is likely to be forthcoming from groups of ranchers cooperating with each other, as well as from the larger artificial insemination organizations.

Brucellosis in goats and sheep

G.G. ALTON *

Brucellosis is now considered to be the most important disease, in terms of the amount of suffering caused, that human beings contract from animals. Also known as Malta, Mediterranean or undulant fever, it is a true zoonosis in that each human case is acquired from animals, there being virtually no human to human transmission. Goat and sheep brucellosis is the type that causes most human infection.

Brucellosis in man has long been associated with the island of Malta, mainly because of the investigational work that has been done there. The accurate description of Malta fever by Marston in 1861, the isolation of the causal organism by Bruce in 1886 and the discovery by Zammit at the beginning of the present century that the reservoir of the infection was to be found in goats, were all landmarks in the understanding of the disease and allowed preventative measures to be formulated. When British troops on the island were forbidden to drink goat's milk Malta fever virtually disappeared among them.

Subsequent to Bruce's discovery, a similar organism was shown to be the cause of contagious abortion in cattle, and some years afterwards another similar organism was shown to be the cause of abortion in swine. In honour of Sir David Bruce, these three bacteria are now called *Brucella* and the disease they cause brucellosis.

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The sheep and goat bacterium is known as *Brucella melitensis*, the cattle bacterium *Brucella abortus*, and that of the pig *Brucella suis*. While all three species are capable of infecting man, *Br. melitensis* is by far the most troublesome.

Geographical distribution

Brucellosis of goats and sheep has centred in the northern and eastern Mediterranean lands, including the islands of Sicily and Malta, and eastward into Asia. Spain, southern France, Italy, Greece and Turkey are heavily infected and this area of heaviest infection extends as far eastward as Iran, the southern and eastern parts of the U.S.S.R. and Mongolia. In some of these areas the problem has recently been reduced by remedial measures.

Areas where *Br. melitensis* infection is prevalent, but somewhat less so than in the primary focus, include India and Pakistan, the more southerly areas of the Near East and most parts of Africa including the Mediterranean coast. In recent years some of the oil-rich countries of the Near East, wishing to improve the lot of their pastoral and nomadic populations, have begun to import goats from the countries that constitute the primary focus of brucella infection. Unless great care is taken this process is likely to result in further dissemination of the disease.

It is commonly believed that brucella infection spread eastward and into Africa with the movement of Mediterranean peoples and probably crossed the Atlantic with animals belonging to early European settlers. *Br. melitensis* in goats and humans is prevalent in parts of Latin America from Mexico to northern Argentina and isolated outbreaks still occur in the southern United States.

The nature of the disease in goats and sheep

Abortion is the principal manifestation of brucellosis in goats and sheep and this produces a massive contamination of the environment from the enormous numbers of brucella organisms found in the foetuses, placentas and fluids of infected animals; vaginal excretion of brucellae usually persists for about three months after abortion. Excretion on a lesser scale occurs via the milk, urine and faeces. Floors of goat pens become contaminated and the goats after lying on such contaminated surfaces clean themselves with their tongues and thus facilitate the transport of infection to the mouth which is the principal portal of entry.

Br. melitensis may be inhaled, along with dust, or it may enter the body through the eye and even through the intact skin. The act of abortion seems to be the most potent factor in providing a mass of infection sufficient for transmission. In the absence of good hygiene, impermeable stone or concrete floors

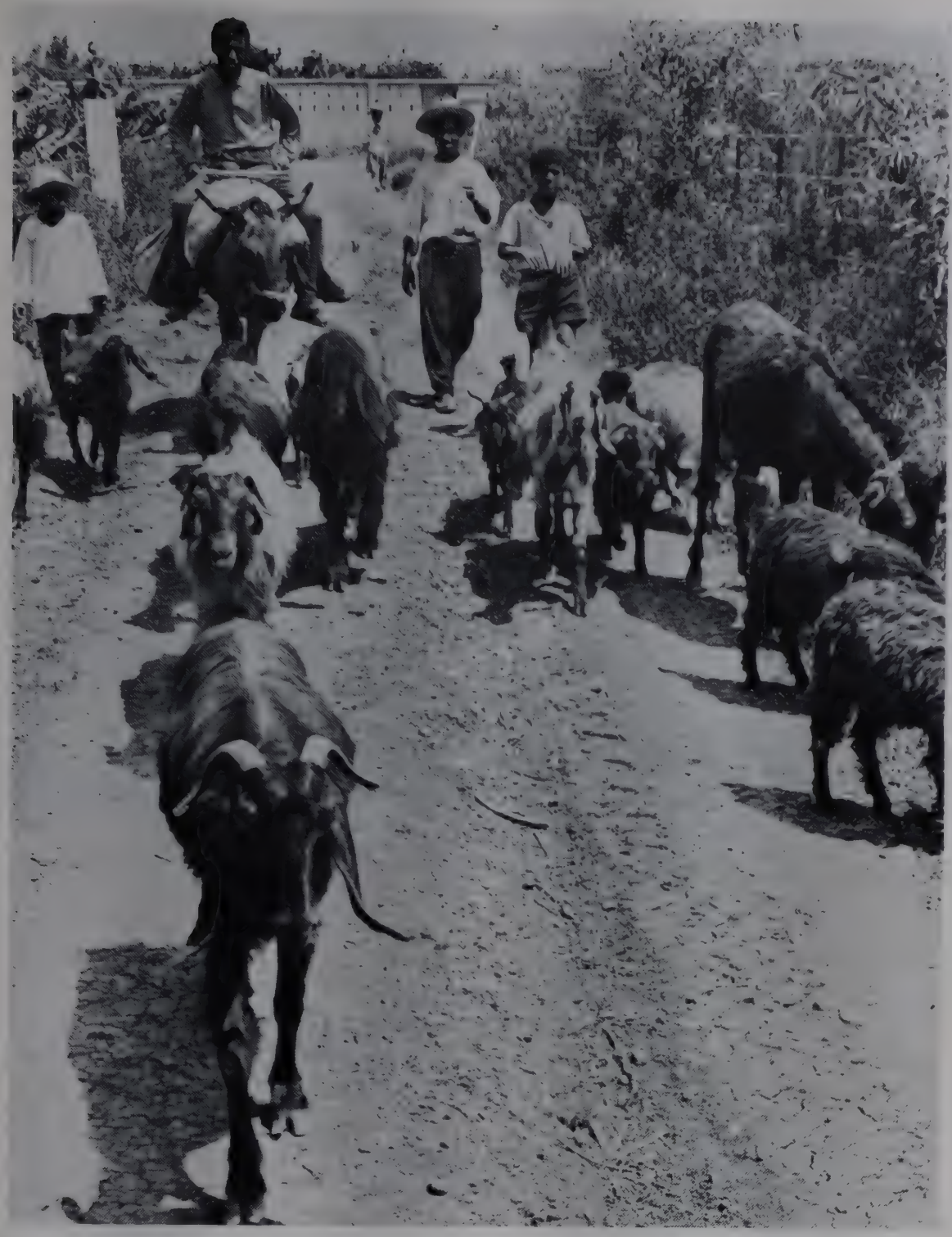

FIGURE 1. Brucellosis is particularly common in goats in the Mediterranean basin and the Near East countries.

seem to facilitate spread of the disease more than permeable floors covered with bedding, or desert sands which have the ability to absorb infective material. The male goat may suffer orchitis (inflammation of the testicle), and *Br. melitensis* may be present in the semen of infected goats but the male animal does not seem to play a major role in disseminating caprine brucellosis.

After entry into the body the organism enters the lymphatic system and reaches the lymph node draining the region of entry. If the infection is sufficiently powerful to overcome the resistance of the regional lymphatic system the organisms will enter the blood and the infection becomes generalized. If the animal is pregnant brucellae are likely to proliferate to enormous numbers in the uterus, causing abortion, and to a lesser extent in the udder where a mild attack of mastitis may occur. Usually no other signs are present; later the disease becomes chronic and localizes in the udder. Some infected goats abort only once, others repeatedly; some goats giving birth at the normal time excrete brucellae in large numbers. Most goats rid themselves of infection, but this may take years.

Sheep are in general less susceptible to *Br. melitensis* infection than goats, but there are marked differences in susceptibility between breeds. The Maltese sheep is highly resistant and almost invariably remains free despite heavy exposure, whereas the fat-tailed Awassi breed of the Near East is much more susceptible and numerous abortions with copious excretion of *Br. melitensis* may occur in recently infected flocks. Even in the most susceptible breed the individual animal rids itself more rapidly of the infection than do goats. The male sheep appears to play a greater part in the transmission of the disease than does the male goat. Brucellosis in sheep caused by *Br. melitensis* is an entirely different disease from ram epididymitis caused by *Br. ovis*, a recent addition to the genus *Brucella;* this latter is a disease primarily of the male sheep and there is no record of its transmission to man.

Economic and public health factors

The frequent occurrence of abortion causes a loss of lambs or kids needed for revenue or for raising as replacements for uneconomic adults. The abortion factor is important economically especially to the karakul breeder. Following abortion there is generally much reduced milk production which is especially detrimental to the owner whose livelihood depends on selling milk.

The presence of *Br. melitensis* infection means that the farmer and his family are themselves likely to contract brucellosis. Brucellosis in humans produces an undulating and debilitating fever which in the absence of expensive antibiotic treatment may persist for months and sometimes even years; chronic lesions in bones and joints may follow. Goat owners are usually peasant farmers and least able to support the loss of revenue caused by brucellosis in the herd, and also least able to afford expensive treatment for themselves and their families.

Br. melitensis can infect not only humans; it also readily infects cattle and is able to cause abortion and

FIGURE 2. Shepherd leading flock of sheep and goats in Egypt. Owners are usually peasant farmers and least able to support the loss of revenue caused by brucellosis in the herd.

spread of infection among pregnant cattle. This means that where infected sheep and goats are present, schemes for the eradication of bovine brucellosis must also include its eradication from sheep and goats.

Control measures

Until about 30 years ago control measures for sheep and goat brucellosis were hampered by a lack of knowledge of the diagnosis of chronic cases and the absence of a preventive vaccine. Efforts made by United Nations agencies in disseminating information and promoting research have contributed to the much improved situation obtaining today when reasonably effective methods are available for both vaccination and diagnostic tests.

In some areas conditions are so difficult that vaccination will remain for some time to come the only practical method of control. In other areas the incidence of the disease may be so high that the elimination of large numbers of reacting animals would not be economically feasible and vaccination will be required to bring the incidence down to a level where more radical measures become practicable.

Vaccination alone, however, is not likely to achieve eradication and technical methods are now available for eliminating brucellosis in goats and sheep by test and slaughter, even in the primitive conditions under which they are kept in many countries.

VACCINATION

The living attenuated *Br. melitensis* strain Rev. 1 was developed at the University of California by Professor Elberg and his colleagues (Herzberg and Elberg, 1955). Searching for a living attenuated vaccine these workers isolated a streptomycin-dependent mutant from a culture of *Br. melitensis*. This mutant proved to have no value as an immunizing agent but a nondependent reverse mutant (hence the name, Rev. 1) isolated from the streptomycin-dependent culture was shown to have excellent immunizing properties and to be of reduced virulence.

One injection of the living *Br. melitensis* Rev. 1 vaccine will protect a goat for the rest of its life. Unfortunately, if administered to adult goats Rev. 1 may cause abortion if they are pregnant and it may be excreted in the milk if they are lactating. For these reasons it is recommended that Rev. 1 in full doses should be used on young goats from the age of three months up to one month prior to the first mating. Investigation has shown that Rev. 1 is equally useful in protecting sheep against *Br. melitensis* infection (Jones *et al.*, 1964).

The production and testing of Rev. 1 vaccine have been described by Alton and Jones (1967). A review of the first ten years' experience with the vaccine has been published by Alton and Elberg (1967). Transmission experiments in both sheep and goats revealed no tendency for the Rev. 1 strain to become more virulent, indicating that the degree of attenua-

tion was stabilized. After vaccination with Rev. 1 sheep and goats become positive to most diagnostic tests; the duration of the positive reaction varies between the different tests. Rev. 1 has now been used successfully for vaccinating goats and sheep in several countries including Malta, Italy, Israel, Iran and Peru.

Recent experiment has shown that if the vaccine is injected into adult goats, pregnant or otherwise, in much reduced doses (5×10^4 cells as compared with 10^9 cells in the full dose) neither abortion nor excretion occurs (Alton, 1969, 1970; Alton *et al.*, 1972). Furthermore, the reduction in dose level brings about a great curtailment of the serological response that follows vaccination with full doses. It was thought at first that lowering the dose of Rev. 1 given to goats also lowered the level of resistance induced. However, in the last of the three studies quoted above the immunity induced by the two different dose levels was substantially the same and considerably higher than that induced by a *Br. abortus* 45/20 adjuvant vaccine. The reduced dose method has been shown to be safe in the Mediterranean area and in Latin America; nevertheless, before it is introduced into other areas where goats may have a different level of susceptibility its field use should be preceded by experimental determination of its safety. This method, so far as is known, has not been used in sheep and the reduced dose recommended for goats is not likely to be appropriate for sheep because of their different level of susceptibility.

Br. abortus strain 19, the vaccine widely used to control bovine brucellosis, has been successfully used for protecting sheep in the U.S.S.R. against *Br. melitensis* infection. The immunity appears to be on a rather low level and vaccination needs to be repeated annually.

Eradication by identification and disposal of infected animals

In mounting eradication campaigns the cooperation of both medical and veterinary authorities should be enlisted and the objectives and advantages fully explained to all concerned, especially to owners of sheep and goats. The support of financial authorities is essential to ensure the success of eradication campaigns as it is usually necessary to provide financial inducement in the form of a higher milk price where practicable, or a per caput payment for brucellosis-free herds. The eradication of animal brucellosis will automatically eliminate the human disease in that area and this is one reason among many justifying the expenditure of public funds on incentive payments to the owners of brucellosis-free herds.

In this type of eradication programme periodic testing at short intervals, for example every two months, with disposal of reacting animals, is necessary until each flock is free. Thereafter check tests at longer intervals will be necessary to ensure that flocks remain free.

In many areas the numbers of sheep and goats involved are very large indeed and this will influence the choice of diagnostic test to be used. A practical way of tackling this problem is to use a simple and rapid method such as the skin test for screening to determine which flocks are infected, and to follow this up by periodical serological (blood) tests on individual animals in the flocks where the screen test has revealed the presence of infected animals. In areas where numbers are smaller it may be more satisfactory to bleed and test all animals serologically.

A new skin test for diagnosing brucellosis in sheep and goats has been developed in the U.S.S.R. (Orlov and Kas'yanov, 1968). The antigen called brucellin VIEV is injected under the skin of the lower eyelid. An easily recognizable swelling of the lower eyelid develops in positive reactors. The skin test cannot be relied on to detect every infected individual and this is why it is recommended for screening.

The agglutination test may be used for serological diagnosis in areas where vaccination has not been practised. The tube agglutination test is preferred but the plate test, which can be done in the field, may also be satisfactory. Where adequate laboratory facilities exist the complement fixation test is the method of choice for individual diagnosis. The reaction provoked by vaccination with full doses of Rev. 1 has almost always become negative by six months after vaccination. Provided the cold fixation method is used the complement fixation reaction can be reduced to one tube per sample, positives being retested with an extended test. The percentage of positives has to be fairly low to make the one-tube procedure worth while.

It is preferable that reacting animals be disposed of immediately by slaughter; where this is not practicable arrangements may be made for segregation of reactors pending disposal. Precautions need to be taken to prevent the entry of new infection into the flock during and after eradication. It must be remembered that where goats and sheep in a village are taken out to common grazing grounds, any eradication attempt will need to include the whole village and not just the flocks belonging to individual owners.

General measures of control

Control measures, whether involving vaccination or not, should aim at raising the standard of environmental sanitation in order to lower the intensity of exposure of animals to infection. Attention should be paid to housing conditions, isolation of aborting animals, disposal of aborted materials, disinfection and segregation of infected animals, and so on. The fifth report of the Joint FAO/WHO Expert Committee on Brucellosis (1971) contains much valuable information on this and other matters.

Protection of humans against infection

Human infection in the vast majority of cases results from either handling infected animals or materials contaminated by them, or consuming animal products containing bru-

FIGURE 3. Technicians prepare to test milk samples for brucellae at the Animal Health Institute, Abu Ghraib, near Baghdad.

cella organisms. Other less frequent paths of transmission include the breathing of contaminated dust and the consumption of vegetables or water contaminated by infected animals.

Animal attendants should wear protective clothing and take care in personal hygiene. Animal products likely to contain brucellae should be rendered safe by heat treatment or not consumed at all. Fresh milk is made safe by pasteurization or boiling (momentary boiling is sufficient). Cheeses are dangerous, especially fresh cheese, and in areas where sheep and goat brucellosis occurs they should be avoided. Meat is made safe by ordinary cooking processes.

Vaccination, as a supplement to sanitary and hygienic measures, may be considered for protecting humans where there is a great danger of occupational infection, for example, for sheep and goat handlers, for abattoir workers and for veterinarians and laboratory workers. The Russian living vaccine called 19-BA is administered by skin scarification to persons who are negative to the allergic skin test. The vaccine is capable of causing pathological manifestations in sensitized individuals but is without unpleasant effects if administered according to instructions.

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Mastitis control – the development of a simple and practical control routine

F.H. Dodd *

Udder diseases are a major problem wherever commercial methods of milk production are practised, in spite of extensive international research, the widespread use of antibiotic therapy and hygienic methods. It has been estimated that in the United Kingdom the annual losses due to mastitis exceed £20 million per year and that the figure in the United States is $500 million per year. Why is it that mastitis, almost alone among the major infectious diseases of dairy cattle, has not been controlled? Is it that the recommended methods do not work or that good systems are known but farmers do not adopt them? This article examines the problems and traces the development of a practical routine which is effective over a wide range of conditions.

Many sources of infection

Mastitis, or intramammary inflammation, can arise for many reasons but the disease of economic importance is due to bacterial infection of the udder. Over 90 percent of infections are caused by staphylococci and *Streptococcus agalactiae*, *Str. dysgalactiae* and *Str. uberis*, but many other bacteria and microorganisms such as fungi and yeasts can be responsible.

The primary sources of pathogens causing the disease are infected udder quarters; the bacteria are spread from cow to cow, mainly during milking, on the milker's hand, udder cloths and the milking machines. Where skin lesions of the teat and udder surface are common these become infected with the pathogens and can also be a very serious source of bacteria. In the case of coliforms and pseudomonads the main source will be from bedding, contaminated water and improperly cleaned milking equipment. The disease is, therefore, an occupational hazard for dairy cattle with the commercial routines inevitably increasing the sources of infection, the transfer of pathogens from cow to cow and also, to some extent, the bacterial penetration of the udder through the streak canals of the teats.

The pattern of the disease

Most animals calving for the first time are uninfected, pathogens cannot be detected in aseptically taken milk samples and the leucocyte counts are less than 100 000 per millilitre of milk. On entering the milking herd a cow will be exposed to large numbers of mastitis pathogens from the other (infected) cows and, although the streak canals of the teats normally prevent bacterial penetration of the udder, this occasionally occurs and is followed by an infection.

From this time bacteria can normally be detected in milk samples, the milk has a changed composition, the leucocytes will probably exceed 500 000 per millilitre and the yield of milk declines. At this stage the infection is usually *subclinical*, the milker does not detect any abnormality or inflammation and in fact many infections recover spontaneously without ever being detected. Those infections that persist sooner or later become *clinical*, showing obvious inflammation and gross changes in the milk (clots or blood). At this stage therapy is given, usually intramammary infusions of antibiotic

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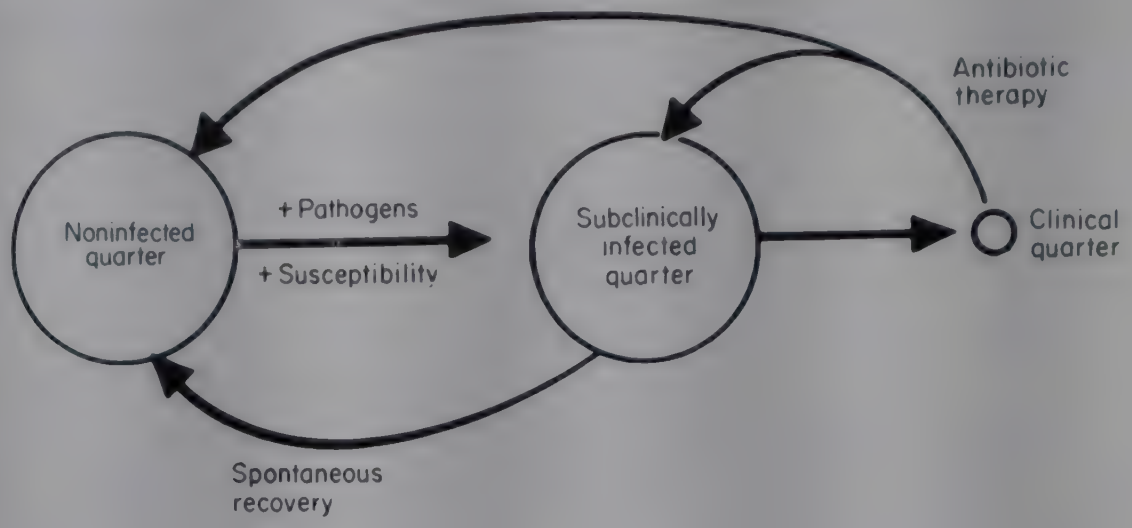
FIGURE 1. The pattern of intramammary infection and clinical mastitis shows that, at any time, only a small proportion of infections show clinical signs, antibiotic therapy does not always eliminate infection, and some subclinical infections recover spontaneously.



preparations, and the clinical signs nearly always disappear though the infection may not have been eliminated (Figure 1).

Most cows that remain in commercial dairy herds for two or more lactations will become infected at least once. In a large population it is common to find 1 to 2 percent of cows with clinical mastitis at any one time but about half will have at least one quarter subclinically infected.

A strategy for control

Unfortunately, techniques that have been very successful in controlling other major cattle diseases are ineffective with mastitis. The disease cannot be completely eradicated from all herds because many pathogens are common in the environment and successful methods of immunization have yet to be devised. Diagnosis of infections followed by treatment cannot be a control system, because the costs of diagnosis are prohibitive and the effectiveness of antibiotics against staphylococcal and some other pathogens is not very good. Finally, breeding cows for greater resistance would be difficult to organize and its effect very slow. Therefore, and on this there is general agreement, *control should be based on devising husbandry techniques that prevent new infections.* The problem is to select, from the many factors known or believed to affect the new infection rate, the few that are really important or can be developed into practical routines.

SIMPLE CONTROL ROUTINE

In devising a control two main approaches are possible. It would be possible using diagnostic tests to discover the herds with the greatest mastitis problem. These could be the subject of detailed investigation and, from the information gained, control systems devised to meet the particular needs of each herd. Alternatively, an attempt could be made to devise a simple economic control that works in virtually all herds without requiring diagnostic tests or special investigations. The second approach has been adopted because the high average levels of infection require control practices in virtually all herds. Also, it would not be practical on a national scale to organize regular diagnostic tests in all herds and the information obtained by special herd investigations does not normally reveal the major factors causing infections. This does not mean that diagnostic services and other special investigations are not necessary in a properly coordinated control scheme. They are essential but they should be used to study the failures in the few herds that do not respond to a routine which works in nearly all other herds.

Thus the research problem was to devise and prove simple economic husbandry methods that would prevent most new udder infections in the varied conditions of commercial milk production.

PREVENTING NEW UDDER INFECTIONS

During the last 50 years much research has been reported on the epidemiology, the mode of infection and the effects of the disease on lactation. Although the exposure of the milking cow to pathogens is virtually continuous new infection is relatively infrequent (of the order of one to three new infections per cow per year). Many management factors are known to influence the frequency of new infection and the more important of these are milking methods. The design, performance and use of milking equipment and certain hygiene routines have become accepted as the key factors in a mastitis control programme. Yet this increase in knowledge did not result in a proven control method. Advice to farmers was inconsistent and it was impossible to adopt all the many recommended practices.

In starting the research programme at the National Institute for Research in Dairying (United Kingdom), it was decided to base the control method on reducing the exposure of the udder to pathogens by better hygiene. In this way the method could be made simple and other techniques added at a later date as they were proved. There was good evidence that under "research herd

conditions" hygiene could be very effective, whereas the evidence on the effect of other management factors (for example, milking machine properties) was confused.

Hygiene

The object of hygiene in mastitis control is to reduce the exposure of the cow's teats to pathogens by reducing the sources of the bacteria or by preventing their transfer from cow to cow. The hygiene techniques commonly used, such as disinfectant udder washes and dipping milking machine teatcups in disinfectant solutions before each cow is milked, do not prevent the transfer of large numbers of bacteria. This is because chemical disinfectants cannot be effective on skin, cloth or rubber surfaces with treatment periods of only a few seconds. After much detailed research work, husbandry methods were evolved that reduced the bacterial exposure to low levels. These were:

1. Udder washing with gloved hands and clean running water or disinfectant solution, using a separate disposable towel for each cow (Figure 2).
2. Pasteurizing the milking machine cluster with water at 80 to 90°C for 5 seconds before each cow is milked.
3. Dipping the teats in specific disinfectant teat dips immediately after milking is completed (Figure 3).

Such a routine complicates milking but it was extensively tested as the most complete hygiene system that could conceivably be used under most farm conditions.

The first small-scale experiments showed that this full routine reduced infection rates by 60 to 90 percent. To measure the value of hygiene under varying field conditions two large field experiments were carried out, each using 700 to 1 000 cows, the first lasting 1 year and the second 18 months. The second was a three-way comparison between: a routine with no disinfectant methods, a "full hygiene" routine including all the techniques described above, and the third a "partial hygiene" based essentially on a simple teat-dipping routine. Both the hygiene routines proved to be effective, the full hygiene reduced new infections by about 60 percent and the partial system by nearly 50 percent (Figure 4). Both hygiene routines reduced infections caused by staphylococci and streptococci, but because of the great advantage of simplicity in milking routines further research was concentrated on improving the teat-dipping routine.

Teat dips have proved to be particularly useful because they enable disinfectant solutions of much higher concentration to be used economically. They reduce the general exposure to pathogens, prevent the bacterial colonization of the streak canal of the teat and teat lesions, and aid the healing of skin wounds. The most effective teat dips proved to be solutions of halogen compounds, and sodium hypochlorite (4 percent available chlorine) and iodophors (0.5 percent available iodine) proved to be particularly effective.

At this stage in the research a simple practical method of reducing the *new infection rate* by about 50 percent had been devised and proved under a range of farm conditions.

FIGURE 2. A gloved hand and running water is one of the best methods of udder washing, paying particular attention to cleaning teat orifices.

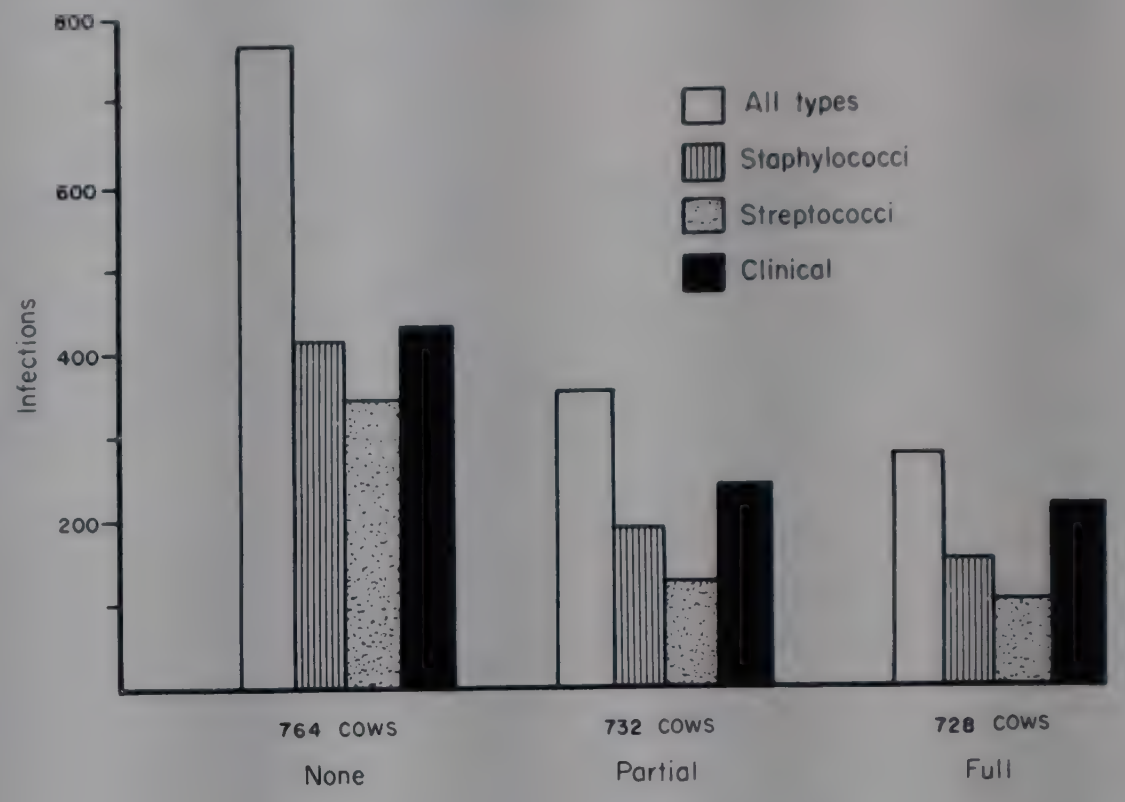
PHOTOS: ESSO FARMER, LONDON

FIGURE 3. After milking is completed immediately dip each teat in a suitable disinfectant.

The routine was expected therefore to reduce the *levels* of infections (that is, percentage of cows infected) by an equal amount. Unfortunately the field experiments showed quite conclusively that even with a marked decline in the rate of new infection the rate of decline in levels of infection was only about 10 percent in the first year. It was so slow that farmers would not be able to detect the improvement. The reasons for the stability of levels of infection proved to be the high average duration of infection. Over 30 percent of infections present at the end of the first field experiment had been detected one year previously!

A control system designed to be effective within a year of adoption must thus incorporate techniques for reducing the new infection rate and also the *duration* of infections. This was the second main task in the research programme.

FIGURE 4. The effect of hygiene on new infections and clinical mastitis in lactating cows. Three routines were compared in 15 herds — none: no disinfectant methods; partial: disinfectant udder wash, individual cloths, rubber gloves, disinfectant hand dipping, teat dip; full: same as partial, plus pasteurized clusters (Dodd *et al.*, 1969).



REDUCING THE DURATION OF INFECTIONS

Infections that do not recover spontaneously are eventually eliminated from a herd by antibiotic therapy or when cows are culled. In the first field experiment 2 114 quarters were diagnosed by laboratory tests during the course of the year as being infected. Of these, 7 percent were eliminated by normal herd culling, 19 percent disappeared spontaneously and only 29 percent were eliminated by antibiotic therapy given when the stockmen found clinical mastitis, even though over 1 000 courses of therapy were given to 840 quarters. The main reason this type of therapy is ineffective in *reducing* levels of infection is that the stockmen were able to detect only about 40 percent of the infections that occurred. Nevertheless, because there is no known way of increasing spontaneous recovery and there are quite definite economic limits to increasing the rate of culling, it was essential to find better methods of antibiotic therapy. In practice this meant introducing the *regular treatment of subclinical as well as clinical infections.*

In a national mastitis control scheme there are major difficulties in incorporating the regular treatment in all herds with subclinical infections in lactating cows. Accurate diagnosis of subclinical mastitis requires bacteriological tests and this is quite impractical as a regular system. Also, the costs of veterinary supervision and the discarding of milk contaminated with antibiotics would be prohibitive. An alternative approach is to *treat subclinical infections in dry cows.* If all quarters of all cows are treated with an appropriate antibiotic preparation after the final milking of each lactation, diagnostic tests are not required and there is no danger of contaminating the milk supply. Furthermore, the technique gives an appreciably higher rate of eliminating staphylococcal infections than does lactation therapy and also considerably reduces the high rates of new infection that occur in the early dry period. Such a treatment would greatly reduce the duration of infections.

In conjunction with Beecham Research Laboratories a research programme was mounted to produce a special drying-off therapy product based on cloxacillin. The product was tested in large field experiments and eliminated over 70 percent of staphylococcal and 85 percent of streptococcal infections found at drying off, and reduced new *dry period* infections to low levels.

With the development of an effective method of reducing the duration of infections the basic components of a control system were available. The simple hygiene reduced new infections caused by the major pathogens by about 50 percent and, in conjunction with drying-off therapy, constituted a control that could be expected to reduce levels of infection and clinical mastitis by at least 50 percent in one year and by 70 to 75 percent in two to three years. Further experiments were necessary to confirm the effectiveness of the scheme.

TESTS IN THE FIELD

Two field tests of the mastitis control routine have been completed, the first conducted in the United Kingdom jointly by the National Institute for Research in Dairying and the Central Veterinary Laboratory, and the second in the United States by Cornell University. Both experiments lasted three years; 32 herds were used in the United King-

dom and 27 in the United States (1 500 to 2 000 cows in each experiment). The experiments had the same design and care was taken to see that the farmers followed a simple routine, which was planned to be independent of any laboratory tests. Essentially, the following routine was adopted:

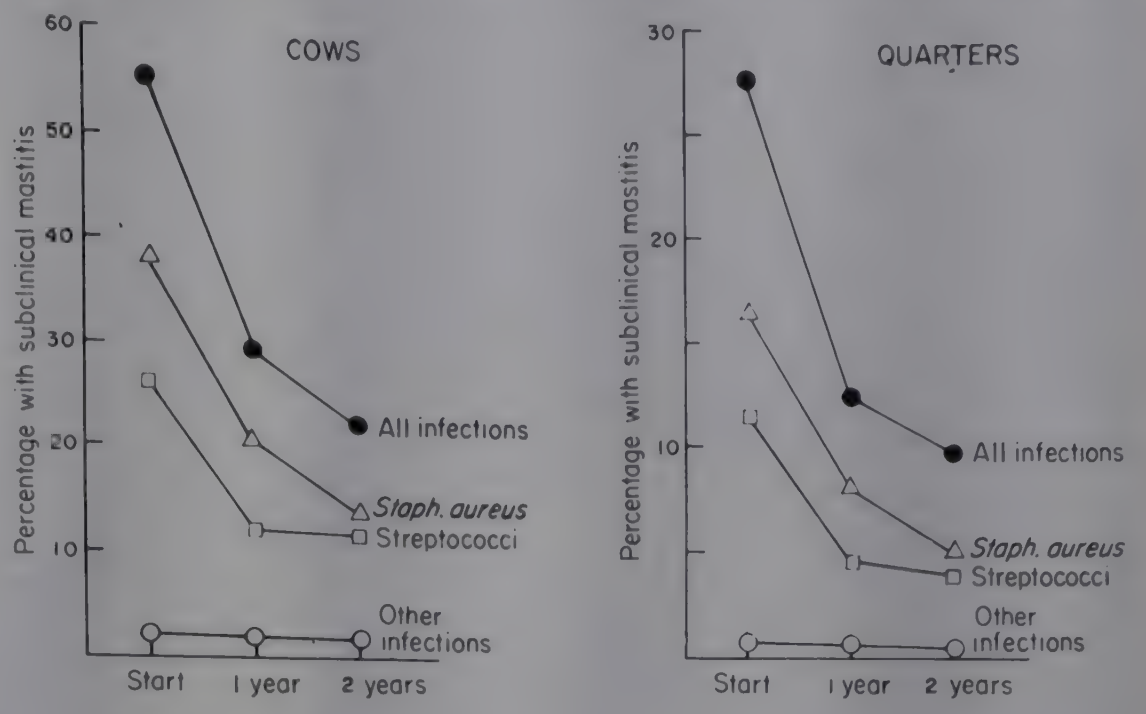
1. Cows' teats were dipped after each milking in a 4 percent hypochlorite teat dip.
2. After the last milking of each lactation all cows were treated with an appropriate antibiotic preparation.
3. Prompt antibiotic therapy was given to lactating cows with clinical mastitis.
4. Cows showing repeated signs of clinical mastitis were culled.

No specific advice was given on the milking routines but the milking machines were tested and faults corrected. To monitor the results of the experiment regular bacteriological tests were made.

Experiments in both countries gave very similar results. The proportion of cows and quarters with subclinical infection fell in one year by about 50 percent, a decline that continued for three years giving a final reduction of about 70 percent. There was a comparable decline in clinical mastitis and the effect was similar for both staphylococcal and streptococcal mastitis. In the United Kingdom experiment *Str. agalactiae* was eliminated from all herds, and while this was not achieved in the United States, there was a very marked reduction. Staphylococcal infections were also eliminated from some herds. As in the initial field experiments, the hygiene system did not appear to influence the frequency of new infection with coliform and pseudomonad infections, but these remained at a low level. In addition to providing conclusive evidence that the control routine was practical and effective these large experiments also demonstrated where improvements were required and the need for further research (Figures 5 and 6).

The most obvious weakness was that, in spite of the fact that in the United Kingdom experiment infection levels declined in all herds with an average of about 70 percent, there were considerable differences in the final levels of the herds. It was apparent that the new infection rates of herds using the same control system varied about tenfold, and that the mean cure rates of staphylococcal infections treated with the same antibiotic varied within 10 to 60 percent from one herd to another. The reasons for these variations were not found from a study of herd differences. It is evident that a further improvement of the control system depends on the solution of these problems. This is the aim of current research.

FIGURE 5. Reduction in the proportion of cows and quarters with subclinical mastitis in 30 herds in the first two years after the introduction of a simple control system (Kingwill *et al.*, 1970).



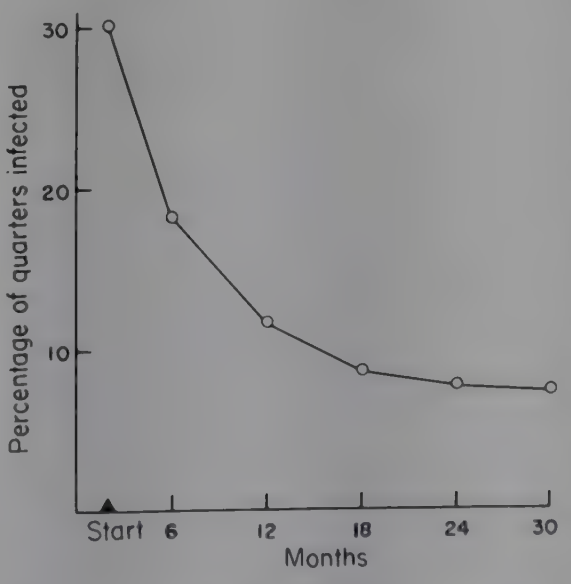


FIGURE 6. Decline in the levels of infection (all pathogens) with a simple control method. These results, which were achieved in the Cornell University experiment, are very similar to those of the equivalent United Kingdom experiment (see Figure 5) (Roberts *et al.*, 1969).

Conclusions

The reader of this article may conclude that this is yet another description of a complex and rather impractical method of mastitis control. If this is so, then the failure is in the description of the research and the results; because the technique is simple, practical and economic and has been shown by most extensive research to be effective over a wide range of conditions. It was developed to meet the needs of a mechanized milk production system but the principles are universal and the routine should work equally well under the simplest hand-milking conditions.

The real attraction is that it does not require any routine diagnostic mastitis tests. A farmer, through his own efforts, can expect to reduce mastitis by 50 percent within a year and see a further reduction in succeeding years. Research continues to improve the routine and to make it easier to apply. Figure 7 shows an in-line filter, now commercially available, that can be inserted in a milking machine to give a much better method of detecting clinical mastitis. Figure 8 shows a trolley for

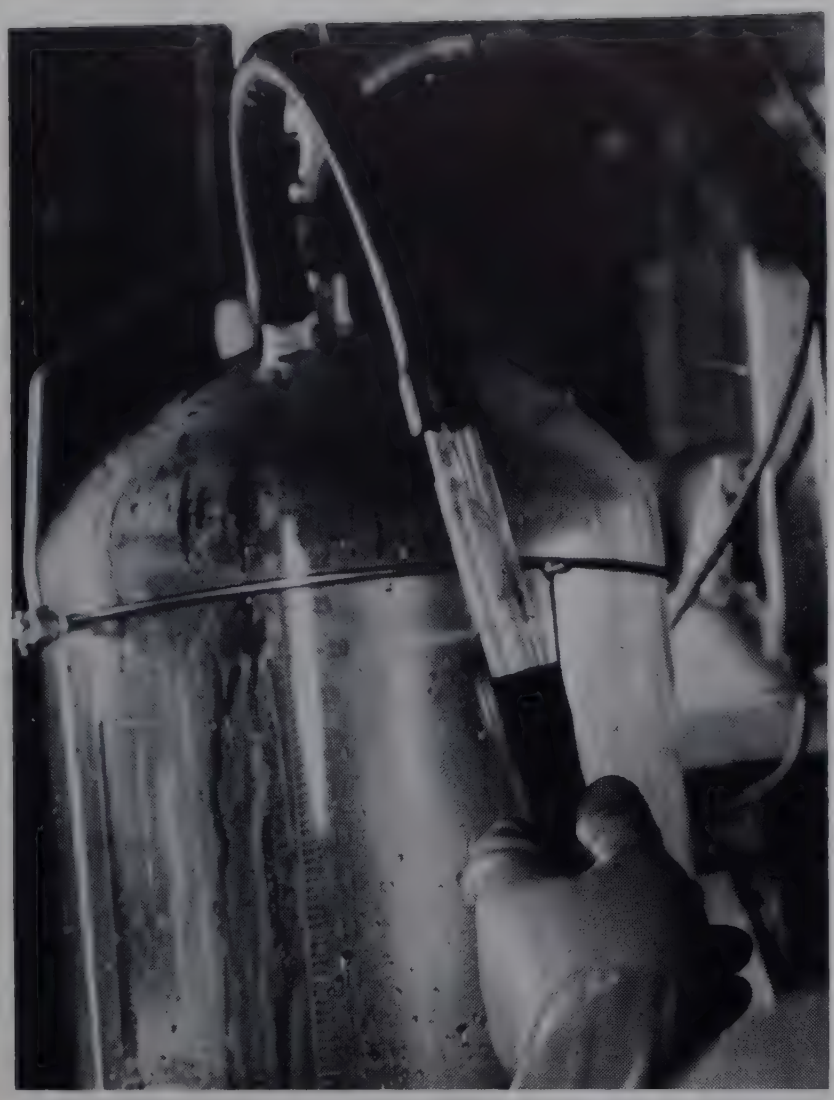


FIGURE 7. A simple filter fitted in the milk line of a milking machine to detect mastitis clots. It is fitted at eye level so that it can be examined after each cow is milked (Hoyle and Dodd, 1970).

PHOTOS: ESSO FARMER, LONDON

FIGURE 8. A simple trolley holds all equipment for the hygiene routine in milking sheds: (A) paper towel dispenser, (B) udder wash solution, (C) teat dip cup, (D) waste bucket.

use in cowsheds to carry the equipment necessary for the hygiene routine.

SUMMARY OF THE ROUTINE

1. Dip all teats in an effective dip as soon as the milking machines are removed or hand milking has been completed. A teat dip containing 4 percent available chlorine with a low alkali content is the most effective dip, proved in the field for control of mastitis. Iodophor solutions (0.5 percent available iodine) are also effective dips. It is important to ensure that the disinfectant used for teat dips is not irritant. Commercially prepared iodophor teat dips are now generally available and in some countries a very cheap and effective dip can be made from the hypochlorite solutions sold as dairy disinfectants. When teat chaps occur an iodophor teat dip containing 33 percent glycerol should be used. There are also advantages in wearing smooth rubber gloves and in examining foremilk *before* washing udders with clean running water or a hypochlorite solution (0.06 percent available chlorine).

2. Give antibiotic therapy as advised by your veterinarian:
   (*a*) to all cows at drying off, using a proven antibiotic designed for this purpose;
   (*b*) whenever clinical mastitis is detected. Always clean the teat orifice carefully with surgical spirit before infusing antibiotic; record all clinical cases.

3. Cull cows with recurring mastitis.

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(Available from: The National Institute for Research in Dairying, Shinfield, Reading RG2 9AT, England.)

Ultra-high-temperature processed milk

H. BURTON *

The value of milk as a foodstuff is well known; its value is particularly great in areas with low nutritional standards and where animal protein is, for one reason or another, scarce. Unfortunately, the very properties which make milk of value in human nutrition also make it subject to bacteriological spoilage, and therefore difficult to transport from the source of supply to the consumer.

Pasteurization

Milk can be made safe for human consumption by pasteurization, that is, by a heat treatment at about 63°C for 30 minutes, or at about 71°C for 15 seconds. Such heat treatment will destroy all pathogenic organisms, but many heat-resistant organisms will survive, particularly bacterial spores. Even very small numbers of surviving organisms will cause spoilage if they are allowed to multiply. The only way of preventing multiplication is by refrigerated storage, with the milk kept at a temperature below about 5°C, but it is usually inconvenient to distribute liquid milk under refrigeration.

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Sterilization

The alternative is to heat-treat the milk much more severely, and attempt to destroy *all* the microorganisms, the spores as well as the vegetative forms, so that bacterial spoilage cannot occur under any storage conditions. That is to say, the milk must be given some form of sterilization process.

Sterilized milk has been produced for some 70 years by an in-container sterilization process, and has been used widely for the non-refrigerated distribution of milk in the industrial areas of western Europe and many other regions. In this process, the milk is homogenized and filled into suitable containers such as glass or plastic bottles which are then hermetically sealed. The containers are heated to a temperature of from 110 to 120°C and held at that temperature for 20 to 40 minutes. The most common heating medium is saturated steam under pressure, contained either in batch autoclaves or in continuous sterilizers, usually of the hydrostatic type (FAO, 1965).

This process is capable of producing milk of good keeping quality with a high proportion of the containers remaining unspoiled for long periods under nonrefrigerated conditions. It is perhaps unfortunate that it is not used more widely in developing countries, because of its comparative simplicity and the fact that it can be applied on a relatively small scale if necessary.

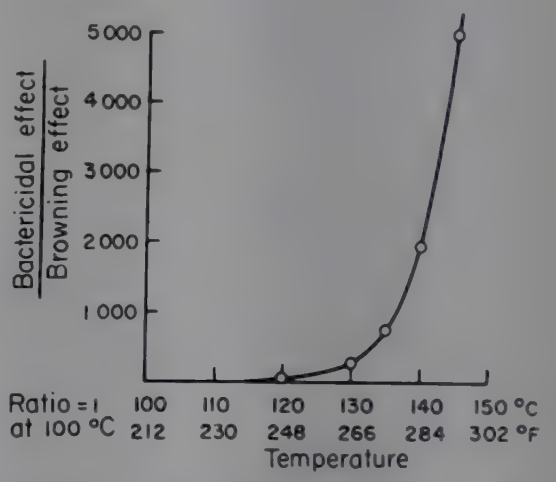
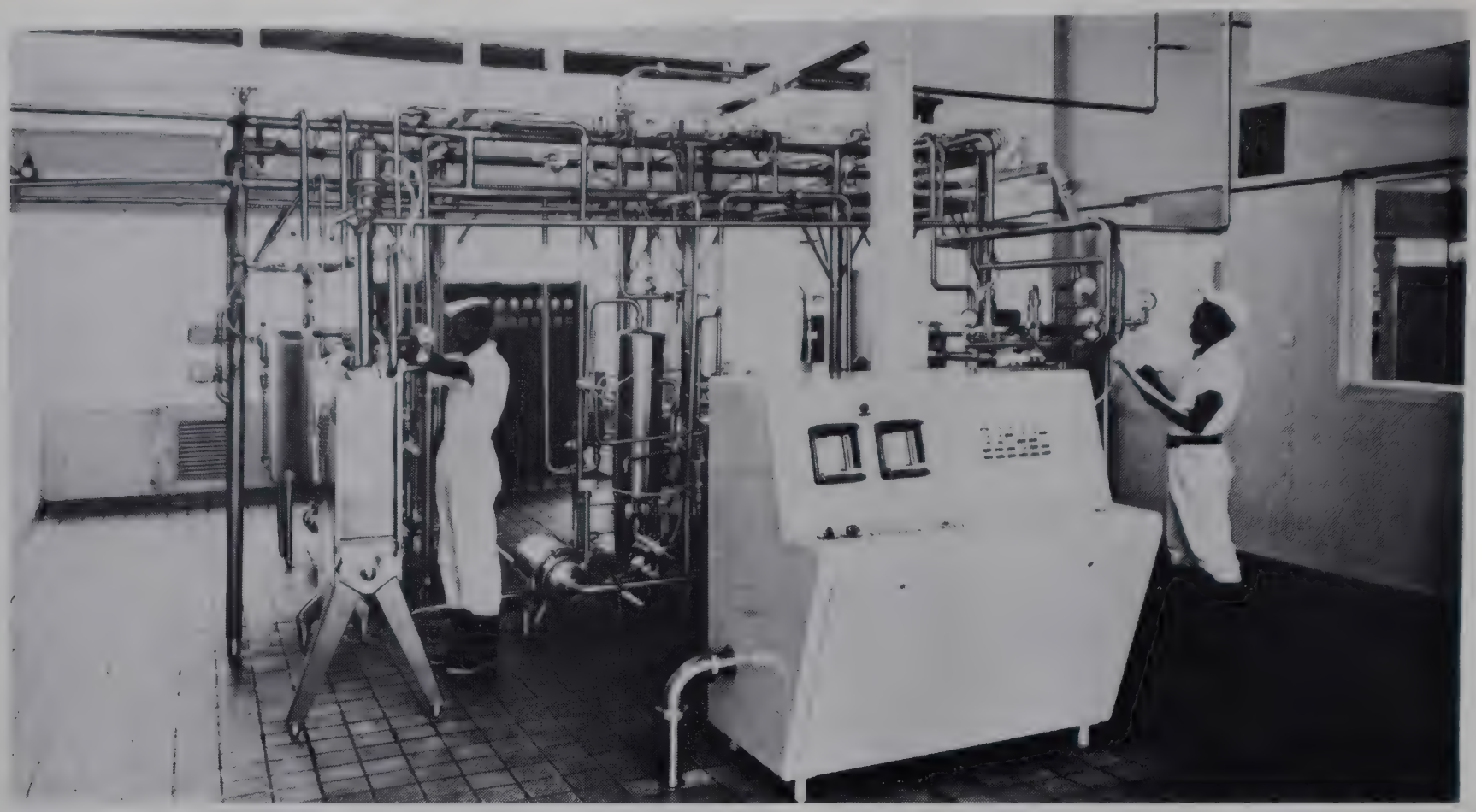


FIGURE 1. The effect of increasing temperature on the ratio of bactericidal effect to browning during milk sterilization. Q_{10} for spore destruction = 20; Q_{10} for browning = 3.

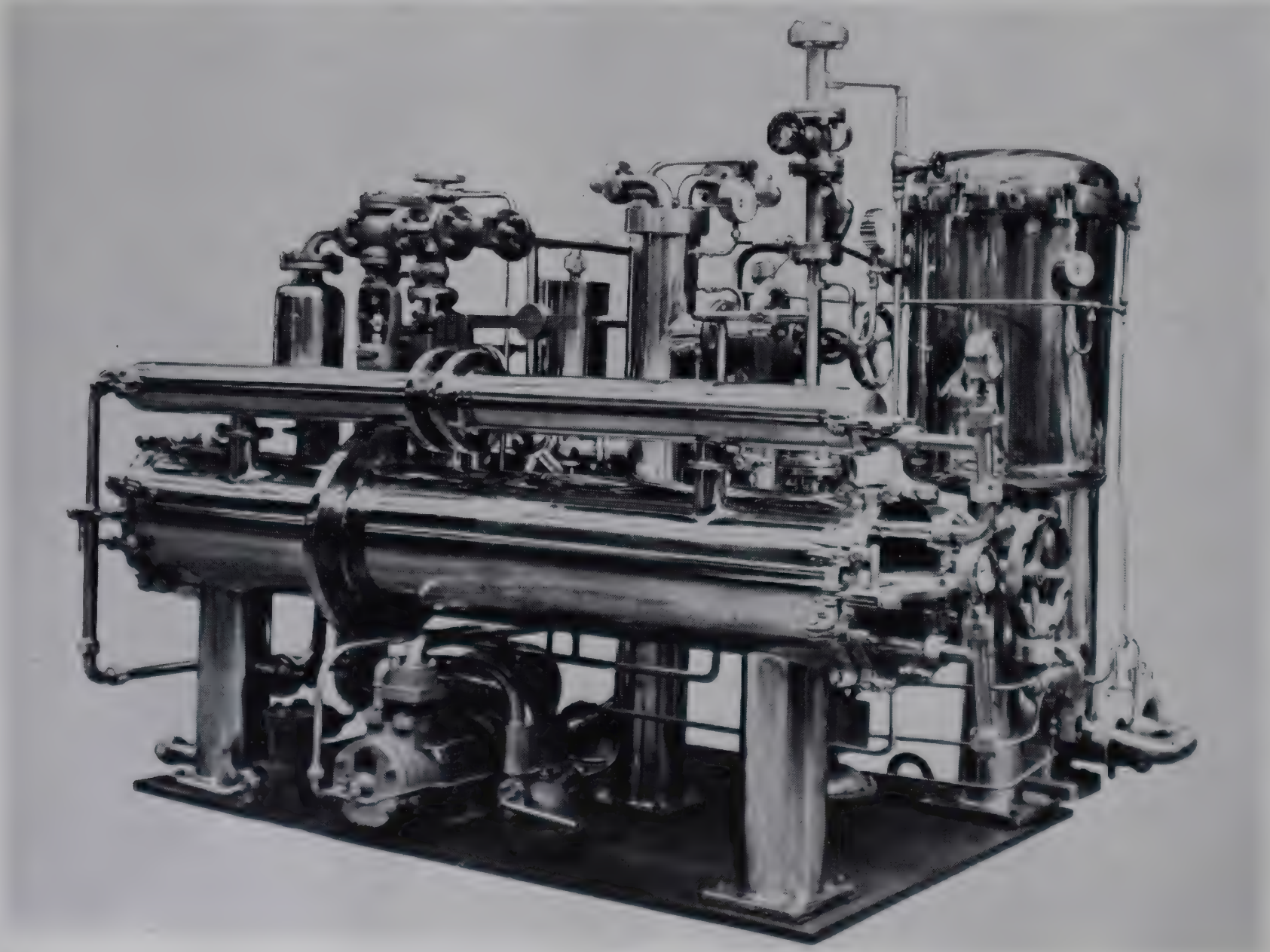
However, some of the characteristics of the milk are changed by the severity of the heating process used. In particular, the milk acquires a strong "sterilized" flavour, and a cream or brown colour, which may make it unacceptable to consumers who are accustomed to unheated milk. These changes are caused by chemical reactions in the milk which must occur whenever a heat sterilization process is applied.



PHOTOS: A.P.V. CO. LTD.

FIGURE 2. A plate-type indirect heating UHT plant at the Kenya Cooperative Creameries Company, Nairobi.

FIGURE 3. An Uperiser(R), type 8000, steam-into-milk direct heating UHT plant.



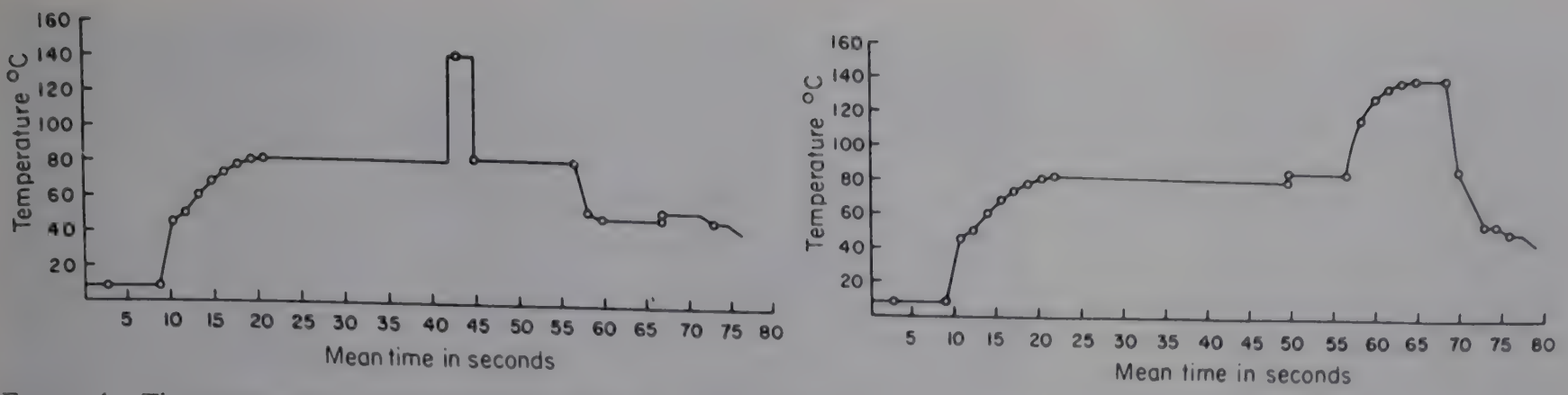


FIGURE 4. Time-temperature curves for direct (left) and indirect (right) UHT sterilizers (Burton and Perkin, 1970).

Ultra-high temperatures

About 50 years ago, it was found that milk heated to much higher temperatures, for example 150°C, for a few seconds was also sterile, but that the adverse chemical changes had occurred to only a very slight extent. Equipment available at that time was not suitable for this process, and the results were forgotten until they were rediscovered in the early 1950s. The reason for the improvement in the quality of milk sterilized at these high temperatures for very short times was only realized later.

The rate of destruction of spores in milk increases by 10 to 30 times for every 10°C increase in the processing temperature (the Q_{10} of the reaction is 10 to 30). The chemical reactions that are responsible for colour change, flavour development, vitamin loss, and so on increase only about 3 times for every 10°C increase in temperature (the Q_{10} is 3). Therefore an increase in processing temperature will give an increase in spore destruction in relation to chemical change (Burton, 1965). This increase is illustrated in Figure 1, where it is assumed that the ratio of bacteriological effect to chemical effect at 100°C is unity, that the Q_{10} of the bacteriological effect is 20, and that the Q_{10} for the chemical effect is 3. The very great increase in the bacteriological effect in relation to chemical effect at temperatures above about 135°C is clearly seen.

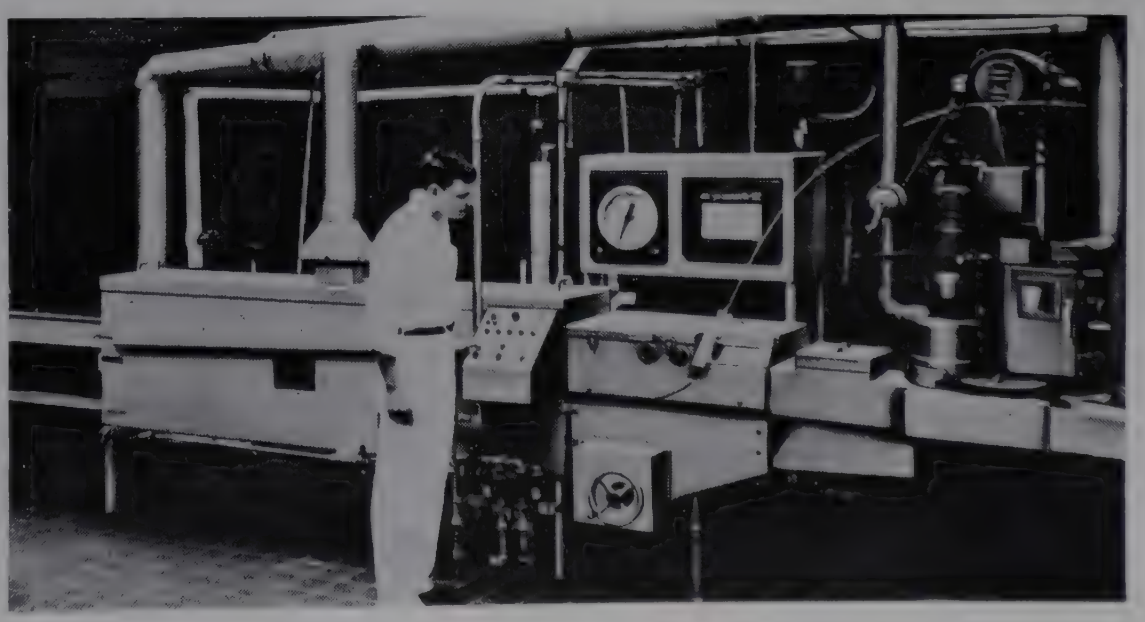
In practice, temperatures in the range 135 to 150°C, with holding times of about 1 to 8 seconds, will give a milk having a level of sterility at least as good as that given by an in-container process, with very much less change in the colour, flavour and other chemical properties of the milk. Such a process is called an ultra-high-temperature, or UHT, process.

The difference in the effects of in-container sterilization and of UHT sterilization is that the sterilizing effect of each process — as determined by the proportion of highly resistant spores surviving the treatment — is related to the chemical effect as determined by the colour of the milk after treatment. The different commercial in-bottle sterilized milks form a related group according to the severity of the heat treatment given to them. A low proportion of surviving spores can only be obtained after a severe heat treatment which gives a brown milk (milk with a low reflectance). Conversely, a light heat treatment which gives a good colour will give a poor sterilizing effect. UHT-processed milk has quite different characteristics. It has at the same time a lower proportion of surviving spores than the most severely heated of the in-bottle processed milks, and a better colour than the least severely heated.

The benefits of a UHT process depend on a high temperature (135 to 150°C) being maintained for only a few seconds. It is not possible to obtain such time-temperature con-

FIGURE 5. An aseptic canning unit.

PHOTO: JAMES DOLE ENGINEERING CO.



ditions with milk held in a container, because the limited rate of heat transfer through the container wall and the mass of the liquid prevent sufficiently rapid temperature changes in the milk. It is necessary to treat the milk in bulk, in continuous flow through a suitable heat exchanger.

This immediately introduces a difficulty. Milk needs to be in a suitable container for distribution. With an in-container sterilization process, the container is sterilized at the same time as the milk, and no special problems arise. UHT-processed milk, however, is sterilized in bulk while flowing through a heat exchanger but, before it can be distributed, it needs to be filled without contamination into containers which have a level of sterility corresponding to that of the processed milk so that its quality is not degraded. Aseptic filling is an operation which is special to the production of UHT-processed milk, and it is quite as difficult — if not more difficult — of achievement as is the sterilization of the milk itself.

PHOTO: AB TETRA PAK

FIGURE 6. Aseptic filler for tetrahedral cartons.

METHODS OF UHT STERILIZATION

UHT sterilization processes can be divided into two main systems, according to the type of heat exchanger used (Burton, 1969). In the *indirect* heating system, the flow of milk is separated physically from the heating medium by a heat-conducting surface which may be a stainless steel plate or tube. The heating medium may be steam under pressure, or hot water circulated under pressure. Such a plant is in fact very similar to a pasteurizer but operating at a higher temperature; it normally includes regenerative heating and cooling sections in the milk-processing circuit. A plant of the plate-type indirect system is shown in Figure 2.

The *direct* heating UHT system involves the mixing of the milk with culinary steam at high pressure. Some of the steam condenses and heats the milk very rapidly, at the same time diluting it by about 10 percent. The steam may be injected into the stream of milk in a suitable mixing nozzle, or the milk may be sprayed into a chamber containing steam under pressure. Whatever method is used for mixing steam and milk to heat the milk to the sterilizing temperature, the heated milk is injected, after holding, through an orifice into a vacuum chamber. The vacuum causes instantaneous boiling of the hot milk, and rapid cooling to a temperature corresponding to the vacuum level. By suitable choice and control of the vacuum level, the amount of water vapour removed during cooling can be made equal to the volume of condensate added during heating, so that the initial milk composition remains unchanged after the treatment. A steam-into-milk direct-heating plant is shown in Figure 3.

Both types of UHT plant are able to give satisfactory bacteriological performance. An indirect-heating process may denature rather more of the soluble proteins of the milk, but this difference has no significance in human nutrition, and the flavour of the processed milk does not seem to be adversely affected by the increased soluble-protein denaturation. The differences between the effects of the processes are caused by the different time-temperature combinations experienced by the milk as it passes through the plant.

Figure 4 shows the time-temperature curves corresponding to the flow of milk through a plate-type indirect-heating sterilizer and through a steam-into-milk direct-heating sterilizer. It can be seen that although the holding times at the full processing temperature are the same in both processes, the effective holding time is greater in the indirect process because of the relatively slow temperature changes. These are caused by the limited heat transfer rates through the stainless steel heat exchange surfaces.

The nutritive value of the proteins

of the milk is not affected by either system of UHT processing, and the losses of heat-labile vitamins are small and similar in magnitude in both systems, as can be seen from Table 1.

Aseptic filling of milk

As has been said above, aseptic filling is essential if the best use is to be made of UHT milk. This involves the sterilization of the chosen container, its filling under aseptic conditions, and the sterilization and aseptic application of any required closure. Only a limited number of processes are available commercially, and these differ widely in principle according to the type of container used (Burton, 1970).

The earliest successful process was for aseptic canning; the cans and lids are sterilized by superheated steam, and the cans are filled and the lids applied and seamed in place in a tunnel filled with superheated steam at atmospheric pressure. An aseptic canning unit is shown in Figure 5. Cans are expensive containers and this filling system is therefore little used for liquid milk, although it is widely used for other more expensive products such as soups, milk-based desserts, and so on.

The most generally used system for liquid milk utilizes cartons made from reels of polythene-coated paper, usually laminated with aluminium foil to avoid oxygen penetration during storage. The paper web is sterilized as it leaves the reel by a combination of hydrogen peroxide and heat, and the container is formed, filled, sealed and separated from the web within a sealed chamber. Machines are available to manufacture and fill either tetrahedral containers (Figure 6) or rectangular containers (Figure 7).

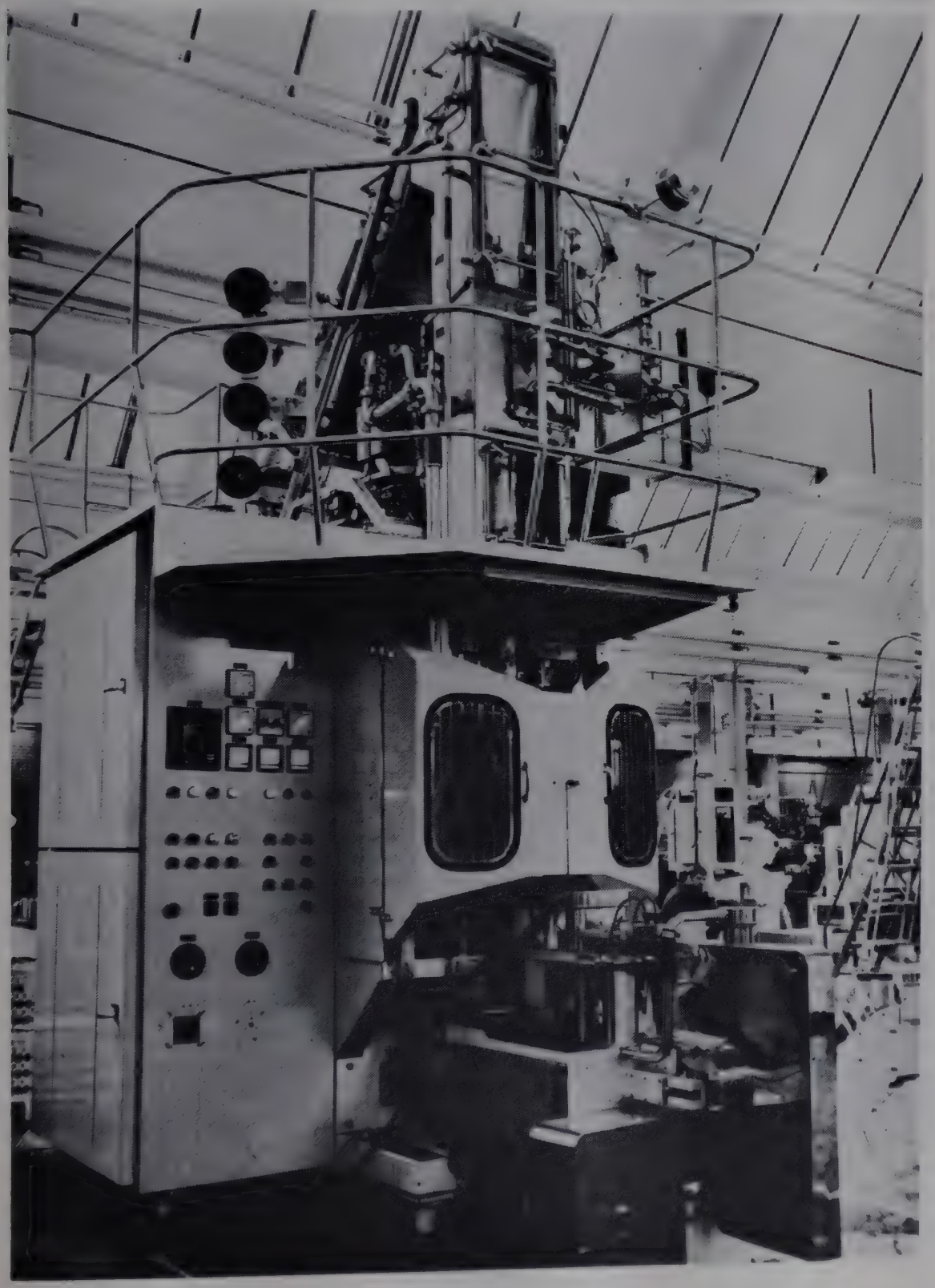
An alternative system does not use laminated paper from a reel, but is supplied with presterilized blanks, which are assembled into rectangular cartons within the machine. The cartons are resterilized with hydrogen peroxide and hot air, and then filled and sealed in a protective atmosphere of filtered air.

Aseptic filling methods for plastic containers, either sachets or blow-moulded bottles, have been developed, but they are used to only a small extent and commercial experience is slight. Some of these methods have the disadvantage that the finished pack is highly permeable to oxygen.

Methods for aseptic filling of glass containers have also been developed, but they are not yet commercial.

FIGURE 7. Aseptic filler for rectangular cartons.

PHOTO: AB TETRA PAK



The effect of storage

The aim of a UHT sterilization-aseptic filling process is to obtain a product free from bacteriological spoilage. This is not possible to guarantee because only a single organism in a pack can cause spoilage. There is a considerable risk that this single organism may either survive the process or enter as a contaminant at some stage. However, experience suggests that a satisfactory system will give a level of bacterial spoilage

TABLE 1. Effect of direct and indirect UHT processes on some of the heat-labile vitamins[1] in milk in three experiments

Experiment	Total ascorbic acid		Folic acid		Vitamin B_6		Vitamin B_{12}	
	Direct	Indirect	Direct	Indirect	Direct	Indirect	Direct	Indirect
	Percentages of the content of the corresponding raw milk							
1	71	71	98	81	93	93	88	94
2	72	71	100	96	82	82	97	95
3	76	77	87	91	100	96	71	100
MEAN . . .	73	73	96	90	94	90	87	96

[1] No loss of thiamine, vitamin A or carotene.

of less than one container per thousand produced, and frequently the spoilage level may be even several times lower than this figure.

In fact, bacteriological spoilage can be ignored in a well-run system. A bacteriological control programme must be applied to the filled containers to show that the plant operation is satisfactory, and to allow action to be taken if the spoilage figure rises too high (Ashton, 1970).

If UHT milk is kept for 6 to 12 months, it is likely to gel spontaneously although it has remained sterile, and this represents the end of its useful life. The reason for this effect is not fully understood.

While the milk is stored its flavour also changes slowly, at a rate which depends on the storage temperature: the higher the temperature, the more rapid the change. There is an initial improvement in the flavour of the milk, which occurs in the first few days after production because of the disappearance of sulphydryl groups liberated by the heat treatment. The flavour remains good for 10 to 14 days, and then there is a slow deterioration. The age at which the milk becomes unacceptable depends on the consumer, but much UHT milk is used up to 6 months after production.

The oxygen content of UHT milk also causes changes during storage. If the oxygen content is normal (about 8 ppm) the ascorbic acid and later the folic acid in the milk will disappear, although they have been unaffected by the heat treatment itself, as shown in Table 1. Within 20 to 30 days they will have been lost entirely (Ford *et al.*, 1969). This may be nutritionally important. However, it can be prevented by removing the dissolved oxygen. This is done automatically in a direct-heating system by the expansion-cooling stage, but an indirect system requires the addition of a deaerator to give the necessary protection to the vitamins.

It has been suggested that removal of the dissolved oxygen spoils the milk. In fact, any such effect is slight and is confined to the first 14 days of the life of the milk; it is most unlikely that UHT milk would be used within this short time.

Conclusions

UHT-sterilized milk, aseptically filled, is a milk that can be stored for long periods without refrigeration, and yet is of good flavour and high nutritive value, especially if oxygen is removed during processing. The plant used for its production is sophisticated, however, and requires very careful control and skilled maintenance. In order to prevent contamination, the heat exchangers, aseptic fillers and associated equipment must be cleaned and sterilized most carefully before any milk is processed; it is obviously useless to sterilize the milk effectively if it is recontaminated from nonsterile plant. Because a very low level of contamination can result in a high level of spoilage, the margin of error between satisfactory and unsatisfactory operation is small.

Effective plant cleaning and sterilization, and the maintenance of satisfactory conditions during operation, can be guaranteed by automatic control systems, but these are likely to be costly.

Finally, the process requires a reasonably large scale of operation; a milk throughput of some 2 000 litres per hour, maintained for several hours a day, is needed to justify its operation.

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Maziwa lala – a fermented milk

P.L. Shalo * and K.K. Hansen **

From time immemorial most African tribes have kept cattle for the provision of meat and milk, as status symbols, wealth and tribal strength, for the beauty of the animals and as a centre of many traditional ceremonies. Cattle were and continue to be used in bridal negotiations.

Cereals have long been the staple food for many African peoples, but meat and milk have been highly prized ingredients of the diet. Meat and fermented milk were foods for the adults and fresh milk was for the children. If a meal of more than one course was planned the order would normally be cereals with green vegetables followed by meat or milk.

The cows were milked directly into gourds in which the milk was stored and used either fresh or after souring. The gourds containing the freshly drawn milk were kept in the coolest part of the house and left undisturbed for two days until the milk had produced a sufficiently high acidity and a firm coagulum. Children often consumed slightly fermented milk, that is, milk with a low acidity. Both morning and evening milk was mixed in one gourd.

Preparation of gourds as milk containers

Milk for fermentation and stirred milk for drinking were kept in straight-sided gourds, but milk intended for butter and ghee making was stored in a globe-shaped gourd. The gourds varied in capacity up to about 5 litres.

Gourds were washed and scrubbed inside with a curved stick, normally from the leaf stalk of a palm

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FIGURE 1 (left). Containers for fermented milk used by nomadic tribes in Kenya. Left to right: small container (300-400 ml) for refreshment in the field (Turkana); larger vessel for milking and storage (Turkana); undercorated gourd for milking and storage (Masai); decorated gourd for storage (Masai). FIGURE 2 (right). Gourd used in west Kenya for fermenting milk to be made into butter and ghee.

tree. The curved end of the stick was crushed into a brush form. Hot water was poured into the gourd and the stick pressed against the side and moved back and forth. For rinsing, two or three lots of very hot water were shaken in the gourd until all the milk residues were removed and the gourd was hot to the touch. It was then placed for a whole day in the sun to dry. Under the strong tropical sun the gourd was dry long before the end of the day, but it was believed that a gourd kept milk better if it was kept long in the sun.

In the evening the gourd was brought indoors and the glowing embers of a fire from a special tree were placed inside the gourd and pressed against the inner wall with a specially prepared palm leaf stalk which had a strong and smoothly curved end. This process was continued and repeated until the whole of the inside of the gourd was covered with a fine layer of charcoal. By the end of the process the gourd was very hot to the touch, the inside temperature being definitely over 75°C. Most of the powdered charcoal was poured out, but some remained and was mixed with the milk. This produced a smooth bluish fermented milk. Special trees were known by experience to produce embers in the fire that could improve the flavour of the fermented milk. Because of the long cleaning procedure a family had to have many gourds which were used in rotation and were very valuable to the family. Among the Masai people gourds are still highly prized.

With this washing procedure one would expect the gourd to be near sterile, but although no effort was made to inoculate the milk with fermented milk from previous lots, coagulation always took place and usually produced a good flavour. A gourd was used twice before the next cleaning was due and it was known that milk from the second use of the gourd coagulated faster, produced a good flavour quicker and did not keep as long as the first. Many people still believe no container produces a better flavoured fermented milk than the gourd.

FIGURE 3. Household pressure cooker and flasks used for sterlizing milk for making the mother starters.

Social changes have come so fast that only a few nomadic tribes still make their fermented milks in the traditional manner. More and more settle as farmers and sell their milk to their local cooperative society, creamery or milk plant. Because fresh milk for sale fetches a very good price the farmers keep less and less milk at home for fermenting. From the nutritional point of view this is probably regrettable.

Industrial production of fermented milks

The urban populations are growing and they must be supplied with increasing quantities of foodstuffs, including milk. Since the town dwellers consist largely of people who have only recently moved to urban areas it is quite natural that they are fond of fermented milks. To meet the demand in Kenya, the Kenya Cooperative Creameries make huge quantities every day and there is almost no limit to how much more could be sold if the people had a greater purchasing power. Two years ago the company bought new equipment, improved the quality, and named their fermented milk *mala*. The name is derived from a Kiswahili word, *maziwa lala*, which means "milk that has slept." Mala is made from a standardized whole milk, fermented by lactic acid bacteria cultures.

From the start of the Dairy Institute at Egerton College, Kenya, almost eight years ago, cultured buttermilk made from skim milk has been produced and sold. The product was cheap, tasty and nutritious. A couple of years ago the product was improved by increasing the content of solids from 9 to 12 percent by the addition of skim milk powder or by draining off some whey as described later. When it is well made the product is viscous, has a pleasing aromatic sour taste and is very nutritious. By draining off the whey the protein percentage is roughly doubled. Under the name *maziwa lala* the product sells very well.

The starter

The most important single factor in the industrial production of a good quality fermented milk is a good starter. That used by the Dairy

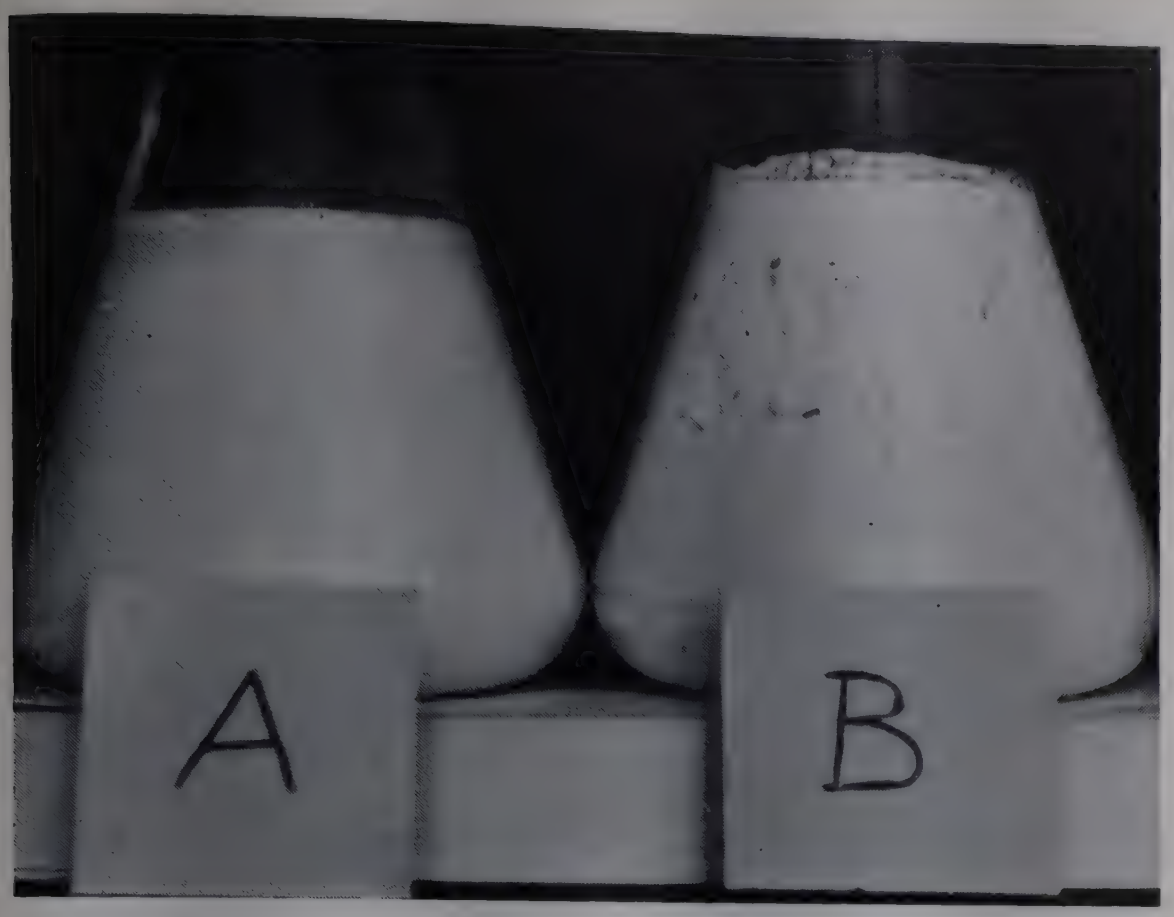

FIGURE 4. Starters: A, normal; B, gassy (contaminated with coliform bacteria). This starter will go putrid in one or two days.

Institute is a lactic acid culture, which is obtained in a freeze-dried condition from a commercial laboratory. It contains a mixed strain culture of acidifying and aroma-producing cocci (species of *Streptococcus* and *Leuconostoc*). This culture can be used for butter and cheese as well as for some fermented milk products. For maziwa lala a mixed strain culture is preferred to a single strain culture. Care must be taken that the good starter is not spoiled in a few days by contamination with harmful microorganisms or bacteriophage.

Starters used to be made in bulk up to 30 litres, and the starter bacteria were transferred from one bulk starter to fresh, pasteurized milk for a new bulk starter. The milk was properly pasteurized at 85 to 90°C for 30 minutes, cooled to 21°C, and all utensils sterilized before inoculation, but after a few weeks the starter would be "slow," perhaps have an off flavour or become gassy. The milk received from farms is quite heavily contaminated with spore-forming bacteria (typical organisms from dust and soil brought into the milk), and they were blamed for much of the trouble. In order to minimize the problem it was decided to make mother starters.

An inexpensive household pressure cooker was bought and the milk for the mother starters sterilized in small flasks at 110 to 115°C for 30 minutes. The starter cultures are now transferred aseptically from one mother starter to the next before being used in bulk starter making. This procedure is successful when sterile pipettes and aseptic methods are employed. Small commercial dairies will probably be unable to use this method, and they should therefore buy a new laboratory culture quite frequently. Milk plants in countries with highly developed dairy industries do this simply by placing a standing order with a commercial laboratory for a new starter culture every week.

TABLE 1. Effect of traces of penicillin on milk sample inoculated with 1 percent maziwa lala starter

Concentration of penicillin in IU per ml milk	Acidity developed after:	
	6 hours	24 hours
	Percent	
Control (no penicillin)	0.21	0.82
0.16 IU	0.19	0.78
1.6 IU	0.19	0.32
16 IU	0.19	0.21

Slow starters are not common in the Dairy Institute, but those in charge of the production of fermented milks occasionally find that their products fail in quality for no obvious reason. One of the dairy technology students has studied the effect of penicillin on yoghurt and maziwa lala starters and he found that as little as 0.16 to 1.6 IU of penicillin per millilitre of milk markedly slowed down the growth of the starter bacteria (see Table 1).

Maziwa lala must have a developed acidity of about 0.75 percent within 16 to 20 hours after the milk is inoculated with 1 to 1.5 percent starter. In one treatment for mastitis 200 000 to 400 000 IU of penicillin may be used. If the entire dose came into 100 litres of milk the concentration would be 2 to 4 IU per millilitre or sufficient to depress the growth of the starter bacteria. Good dairy farmers make sure that milk from treated cows is not sent to the milk plant for the next six milkings, but many cows are treated and the milkers are not always well instructed. It is a worldwide problem for milk plant managers because milk often contains traces of antibiotics, drugs, sanitizers and pesticides.

Starter cultures must be discarded the moment they become slow, too acid, or if they are no longer aroma-producing. Sometimes a starter or a product becomes gassy because of contamination with yeasts, coliform bacteria or spore-forming bacteria. The taste of a starter contaminated with yeasts is sharp and biting on the tongue due to carbon dioxide formation, while coliforms cause an unpleasant "unclean" taste. Contamination is nearly always due to lack of hygiene.

The technique of maziwa lala production

For the production of maziwa lala two methods have been used by the Dairy Institute at Egerton College.

1. With the addition of skim milk powder

Three percent skim milk powder is added to a good quality skim milk and the mix is pasteurized at 85°C for 30 minutes, cooled to 21-22°C and inoculated with 1 to 1.5 percent starter. If the temperature does not drop too much (a very slow decrease to 18-19°C is of advantage for viscosity and aroma) the maziwa lala will be ready in 16 to 20 hours. Too high an acidity may result in wheying off, and it is therefore important that the product be cooled just when it is ready. In large-scale production maziwa lala should be packed in suitable containers immediately, but otherwise it may be kept in milk cans in the cold store, for packaging just before sale or the consumers may bring their own clean containers for the product.

2. With draining of the whey

This method is not as easy as the one mentioned above. Skim milk is pasteurized at 85°C for 30 minutes, cooled to 21-22°C and inoculated with 2 percent starter. As mentioned in the first method a slight drop in temperature is an advantage. The maziwa lala is ready after 15 to 18 hours, but in order to make it more concentrated not less than one third of the volume should be drained as whey. This can be done by "cooking" it, with the water not warmer than 35°C in the jacket of a batch pasteurizer or of a water bath. Gentle stirring is necessary, but it must be done carefully and kept to a minimum. When the product has reached a temperature of approximately 27°C, it is left to whey off for about two hours. The whey will collect at the bottom and it must be drained slowly to prevent the curd from mixing with it. Where possible the product should be homogenized at 500 to 1 000 pounds per square inch (35 to 70 kg per cm^2) before packaging, but pumping or very thorough stirring may be used in small-scale production. Cooling just before homogenization or during stirring is important to prevent wheying off. Too high a temperature of the heating water results in a mealy defect.

Big tanks or batch pasteurizers are used in large-scale production, but the milk can be kept in milk cans which are immersed in a water bath for pasteurization, cooling, incubation, cooking and final cooling.

Packaging, storage and marketing

Maziwa lala can be packed in any of the traditional containers for liquid milk — cans, bottles, paper cartons, plastic bags or plastic bottles. Gas formation may be a problem. If maziwa lala is contaminated with gas-producing organisms, and this can easily happen with unhygienic conditions, the pressure can force the lid off a milk can, the cap off a bottle and more or less explode a paper carton. Plastic bags are more elastic, are seldom filled to more than 80 to 90 percent of their total

FIGURE 5 (left). Maziwa lala being made in a standard milk can immersed in a water bath. The water is heated by steam and the product is then cooled by replacing the hot water with cold. FIGURE 6 (right). Maziwa lala being cultured at 21°C in a batch pasteurizer.

FIGURE 7. Filling and sealing the plastic bags containing maziwa lala.

FIGURE 8. Half-litre pack of mala made by the Kenya Cooperative Creameries, and a half-litre plastic pack of maziwa lala made at Egerton College.

volume but are, however, prone to slow gas penetration. The Kenya Cooperative Creameries pack mala in half-litre tetrahedron cartons without serious problems and in 4-litre cardboard boxes with a sealed plastic bag inside for restaurants, food stalls, etc. The Dairy Institute packs maziwa lala in half-litre plastic bags and, on an experimental scale, in quarter-litre tetrahedron cartons.

The storage conditions necessary are the same as for other liquid, nonsterilized milk products, but of course the acidified products have a superior keeping quality. The temperature of the cold store should be 3 to 4°C.

Marketing does not present any special problems. In Kenya the urban population is growing quickly and the provision of good, protein-rich foods is important. Protein-rich foods are expensive, but milk is among the best and cheapest of such products, although still costly for the common man to buy in adequate quantities for his family's needs. In order to make mala tempting, the Kenya Cooperative Creameries have experimented with flavourings. Surprisingly, smoke flavouring was not very popular, while banana flavour is accepted and would be satisfactory if the taste did not disappear after a few days.

The Dairy Institute at Egerton College developed maziwa lala from skim milk and the result has been very good. The product is rich in proteins and minerals, and is viscous and tasty. It is very popular with adults and also in the nursery schools at Egerton College.

Acknowledgement

The authors wish to express their thanks to P.E. Søgaard, FAO Associate Expert at Egerton College, for help in the work on starters for maziwa lala.

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Animal proteins in human nutrition

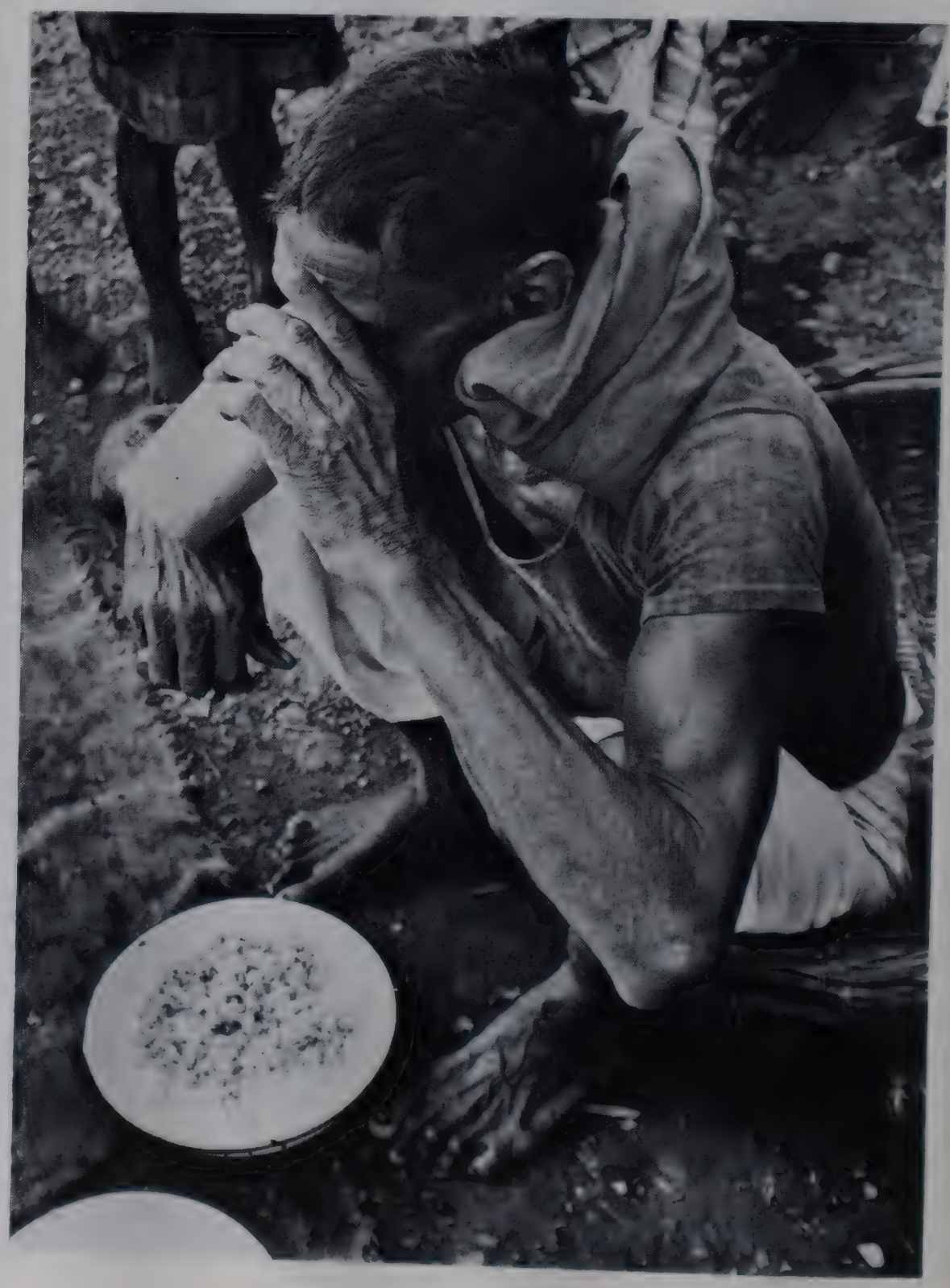
M. Narayana Rao *

The most significant contribution which foods of animal origin (milk and milk products, meat, fish, poultry and eggs) make to human nutrition is in the high quality proteins they supply.

Proteins are essential for human nutrition. Their unique dietary importance had been established by studies on the nature and functions of foodstuffs long before nutrition became a member of the family of biological sciences. With parallel advances in nutrition, biochemistry, physiology, cytology and other related sciences, it became possible to piece together the findings from these separate fields to build up the picture of proteins and their role in the nutrition of living organisms.

In addition to providing the essential amino acids, which are the units from which tissue is synthesized, proteins also serve in the form of nucleoproteins and enzymes, as the activators of vital processes such as reproduction, cell growth, maturation and differentiation, virus activity and genetic activity.

In many developing countries the diet is based on cereals, legumes and tuber flours, and contains little food of animal origin.



Amino acids

Proteins are composed of amino acids, some of which are essential

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and others nonessential or dispensable. According to early studies, any amino acid whose absence in the diet of experimental animals resulted in growth failure or death was classified as essential. Using the growth of rats as criteria, and working with mixtures of purified amino acids, a classification of the 23 amino acids into essential and nonessential was worked out by Rose (1938), after many years of painstaking research. She stated that 10 amino acids were required in the diet of the rat for optimal growth and that the remaining 13 might be omitted from the diet inasmuch as they were probably synthesized in adequate amounts at rates commensurate with the demands for normal growth.

The amino acids required for maintenance of the nitrogen balance in young adult humans has also been studied by Rose (1949). Those essential for the growth of the young white rat, except histidine and arginine, were necessary as dietary constituents if nitrogen balance was to be maintained in human adults. When any one of these amino acids was excluded from the food, a "pronounced negative nitrogen balance, a profound failure in appetite, a sensation of extreme fatigue, and a marked increase in nervous irritability" resulted. With the return of the missing amino acid to the food, nitrogen equilibrium was reestablished promptly and the subjective symptoms disappeared.

The nutritional classification of amino acids is given in Table 1.

TABLE 1. Nutritional classification of amino acids

Essential	Semi-essential	Non-essential
Histidine	Arginine [1]	Glutamic acid
Lysine	Tyrosine [2]	Aspartic acid
Tryptophan	Cystine [3]	Alanine
Phenylalanine	Glycine [1]	Proline
Methionine	Serine [4]	Hydroxy-proline
Threonine		
Leucine		
Isoleucine		
Valine		

[1] Arginine and glycine are essential for chicks and turkeys. – [2] Tyrosine will partly but not completely replace phenylalanine. – [3] Cystine will partly but not completely replace methionine. – [4] Serine will partly or completely replace glycine.

Classification of proteins

Proteins can be mainly classified as those from animal origin and those from vegetable origin. Animal proteins contain more of the essential amino acids than do the vegetable proteins (Table 2) and in general possess a higher nutritive value. The rate of growth in experimental animals such as the albino rat is generally used as a parameter of the nutritive value of protein; in a given time, rats receiving animal proteins put on twice to three times the weight of those receiving only vegetable proteins. Two animal proteins are exceptions, collagen (gelatin) and elastin, both found in the connective tissue of meat.

Newer knowledge of the biological differences among the amino acids led to the classification of proteins as biologically adequate or complete, or biologically incomplete. A biologically complete protein is one which contains all the so-called essential amino acids in adequate amounts for human requirements. Almost all the animal proteins can thus be classified as complete proteins. A biologically incomplete protein is deficient in one or more of the essential amino acids. This deficiency may be absolute or relative. Most of the vegetable proteins are lacking in one or more of the essential amino acids and may therefore be classified as incomplete proteins.

Measuring protein efficiency

The above somewhat elementary distinction between proteins was soon followed by more precise methods of determining nutritive value. The protein quality or nutritive value of protein is usually expressed either as the ratio of gain in body weight to the protein consumed (protein

TABLE 2. Essential amino acid composition of some animal and vegetable proteins

Amino acid	Animal					Vegetable		
	Milk	Egg	Pork	Beef	Chicken	Wheat	Dry beans	Soybeans
	Milligrams per gram of nitrogen							
Arginine	205	381	431	395	348	288	355	452
Histidine	167	152	169	213	164	143	177	158
Lysine	487	436	625	556	497	179	450	399
Sulphur amino acids:								
Methionine	157	210	188	169	157	94	66	79
Cystine	51	152	88	80	82	159	53	83
Total of sulphur-containing amino acids	208	362	276	249	239	253	119	162
Phenylalanine	336	358	288	275	250	282	326	309
Leucine	596	551	563	507	460	417	476	486
Isoleucine	295	393	356	301	334	204	262	284
Threonine	278	320	319	287	248	183	248	241
Valine	362	428	388	313	318	276	287	300
Tryptophan	88	93	85	70	64	68	63	80

TABLE 3. Protein efficiency ratio (PER), biological value (BV) and net protein utilization (NPU) of some proteins

Source of protein	PER	BV	NPU
Egg	4.2	99	98
Milk	3.5	84	83
Pork	2.3	74	71
Beef	2.3	72	70
Chicken	2.4	75	73
Wheat	1.6	68	56
Dry beans	1.4	59	44
Soybeans	2.0	76	62

efficiency ratio, PER) or as biological value (BV) in terms of the percentage of absorbed protein nitrogen utilized in the body. The product of the biological value and the true digestibility divided by 100 gives a value for total protein utilization or net protein utilization (NPU). A good correlation has been observed among these various method of expressing the nutritive value of proteins. Data on the PER, BV and NPU of a few animal and vegetable proteins are given in Table 3.

Block and Mitchell (1946) suggested a method of scoring based on the essential amino acids present in a protein as compared with the amino acids in the proteins of whole egg. The proteins of whole egg are highly digestible and almost perfectly utilized as shown in experiments with both animals and man. Whole egg proteins have a biological value and net protein utilization of 100, and have been used as a standard with which to compare the amino acids from various foods or diets.

Factors which in addition to essential amino acid composition are important in determining the quality of proteins are the availability of amino acids and the digestibility of the protein. Numerous studies have shown that animal proteins, unlike vegetable, are highly digestible, and there is a high degree of availability of amino acids in animal proteins such as those from milk, meat and eggs.

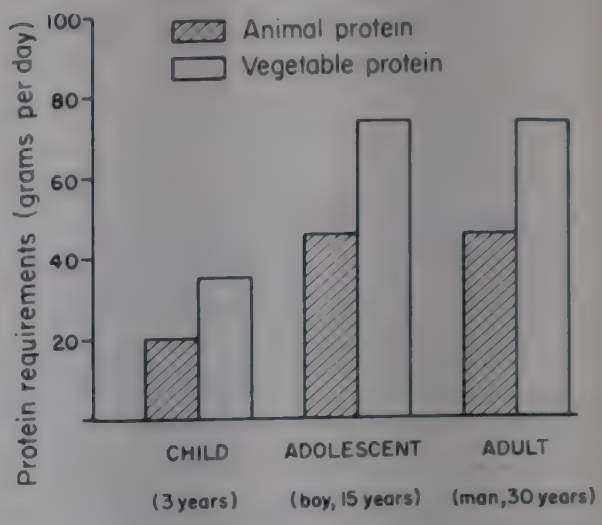
Supplementing vegetable proteins

In addition to being complete and more nutritive, animal proteins possess a significant supplementary value to vegetable proteins, most of which are deficient in the essential amino acids lysine and methionine. Thus animal proteins are used for effectively supplementing poor diets which are based on foods of vegetable origin. It needs to be pointed out here that practical nutrition is concerned with the nutritive value of diets as such and not of individual foods.

The value of pork and milk proteins as supplements to grain products has been illustrated in a study with rats. Equal parts of animal protein from pork or milk and vegetable protein from whole white wheat or rye flour gave as good a growth as pork or milk alone.

The supplementary value of whole milk, skim milk solids and cheese proteins to bread and potatoes has also been effectively demonstrated by biological studies with experimental animals. Similar benefits have been found for beef and cereal protein mixtures. Other studies with rats have shown marked benefits from the supplementation of white bread with skim milk powder. Bread enriched with 6 percent skim milk solids is superior even to bread enriched with thiamine, riboflavin, niacin and iron.

FIGURE 1. Daily animal and vegetable protein requirements of a child, an adolescent and an adult.



Protein in the diet

Human protein requirements, arrived at by many national and international bodies on the basis of growth and metabolism studies in children and adults, can no doubt be met effectively by both vegetable and animal proteins. Difficulties, however, arise with certain vegetable proteins lacking or very deficient in any of the essential amino acids. Requirements of humans can be met

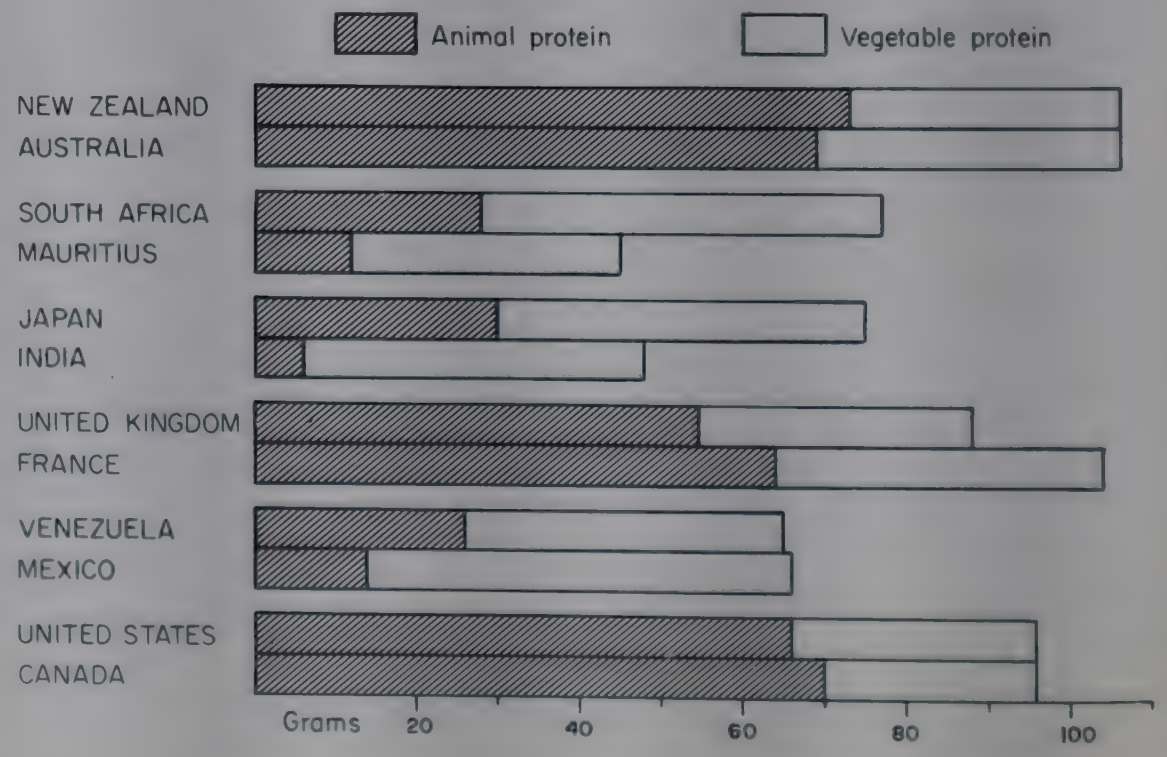


FIGURE 2. Animal and vegetable protein contents of the food supplies available per caput per day in selected countries.

FIGURE 3. Children from Uganda (left) and Guatemala (right) with kwashiorkor, showing oedema of legs, flaky paint rash in groin, thin hair and growth failure. These children could be cured in one month, and become completely normal, if they received daily in addition to their normal diet (usually based on cereals, giving 8 to 10 grams of vegetable protein) four cups of milk and 55 grams of fish or minced meat. This quantity of milk and fish or meat would yield just over 30 grams of animal protein.

by much smaller quantities of animal proteins. Figure 1 depicts the quantities of vegetable and animal proteins required daily by a child, an adolescent and an adult.

There is no doubt that animal proteins are far superior in nutritive value to vegetable proteins. World food diagrams (see Figure 2) reveal that more animal proteins are available in developed than in developing countries. It is also well known that as the economic level of a population increases the consumption of foods from animal sources also increases.

Although the cost of milk and milk powder, meat and eggs is higher than other foods, people in developed countries continue to include more and more of these products in their daily menu. This is brought about by the general increase in buying power coupled with the fact that people enjoy eating these foods.

Protein deficiency

In many developing countries the diet is based on cereals, legumes and tuber flours and contains little food of animal origin. Animal foods are scarce in these regions, and are often too expensive for most of the population.

This lack of good quality animal protein has led to widespread protein-calorie malnutrition, especially manifest in the young (Figure 3) and known as kwashiorkor. This is an extremely complex form of nutritional deficiency, which challenges modern nutritional science.

Most children in areas of malnutrition grow satisfactorily up to an age of six months and their weight development is comparable with that of other children, because their protein requirements are met from their mother's milk. After six months their protein requirements are increased due to demands made first by rapidly increasing growth and second by rapidly developing muscular tissue. If during this period the increased protein needs are not met, there is a growth failure. If the deficiency is more acute, symptoms of protein-calorie malnutrition set in.

Recent research has shown that under such conditions it is not only physical development that suffers but also the child's learning capacity. The brain is the organ that develops

most rapidly in the body. At the age of one year it has already attained 70 percent of its future adult size, and at the age of three it is 80 percent of the adult size. This rapid development occurs just at the time when many children in malnourished regions are not receiving sufficient protein.

The simplest way of preventing protein-calorie malnutrition is the inclusion of adequate animal food in the diet for high quality protein and sufficient dietary energy to permit the protein to be used properly in its functions for growth and the maintenance of health.

Although the high biological value of milk, egg and meat proteins has been well established, their production is less profitable than that of vegetable proteins. Conversion of feed into animal protein is ineffective and expensive even in the best breeds of animals; only a small part of the vegetable protein fed to the animal is recovered in the form of animal protein: 15 to 20 percent as milk protein, 20 to 25 percent as egg and poultry protein, and 5 to 10 percent as beef or pork protein (Leitch and Godden, 1941). However, the world abounds in materials which cannot be consumed by humans but can be utilized by animals for conversion to animal protein.

Increased production and consumption of animal products are the only rapid and efficient solution to the problem of protein malnutrition and undernutrition in the developing countries.

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ARTICLES FOR THE REVIEW

Articles for World Animal Review *are welcomed on animal health or production, or on animal products, especially when they refer to progress in developing countries. It is suggested that intending contributors first write to the technical editor, giving brief details or a summary of the proposed article.*

INTERNATIONAL MEETINGS

26 - 29 March 1973 Ibadan Nigeria	**International Symposium on Animal Production in the Tropics**	Details from: Professor V.A. Oyenuga, Department of Animal Science, University of Ibadan, Ibadan, Nigeria
3 - 4 April 1973 London United Kingdom	**Symposium on Milk Products of the Future**	Details from: Dr. J. Rothwell, Department of Food Science, University of Reading, Reading RG1 5AQ, United Kingdom
4 - 6 April 1973 Mexico City	**National Congress of Food Science and Technology**	Details from: The Secretary, National Congress of Food Science and Technology, Indianapolis N° 63-2, Col. Nápoles, Mexico 18, D.F.
20 - 29 August 1973 Berkeley California United States	**13th International Congress of Genetics**	Details from: Secretary-General, Department of Genetics, 345 Mulford Hall, University of California, Berkeley, California 94720, United States

Any readers who have advance information (more than 12 months ahead) regarding definite arrangements, dates, places, secretaries and addresses of international meetings on animal and related subjects are kindly asked to send such information to the Technical Editor, World Animal Review, FAO, Rome, Italy.

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SELECTED REPORTS ON EDUCATION MEETINGS

1. *Veterinary education*

FAO International Meeting on Veterinary Education, London, United Kingdom, 25-30 April 1960 (119 pages, AN-1960/4). E*, F*, S*

Second FAO/WHO International Meeting on Veterinary Education, Copenhagen, Denmark, 12-21 August 1965 (42 pages, AN-1965/5). E*, F, S.

First Meeting of the FAO/WHO Expert Panel on Veterinary Education, Rome, Italy, 14-23 March 1962 (139 pages, AN-1962/4). E*, F, S.

Second Meeting of the FAO/WHO Expert Panel on Veterinary Education, Rome, Italy, 23 April-2 May 1963 (235 pages, AN-1963/3). E*, F, S.

Third Meeting of the FAO/WHO Expert Panel on Veterinary Education, Rome, Italy, 12-16 July 1971 (62 pages, AGA-1971/7). E, F, S.

2. *Animal production education*

FAO International Conference on Animal Husbandry Education, Göttingen, Federal Republic of Germany, 25-30 July 1966 (47 pages, AN-1966/3). E, F, S.

First Meeting of the FAO Expert Panel on Animal Husbandry Education, Rome, Italy, 30 June-4 July 1969 (56 pages, AN-1969/5). E.

3. *Dairy education*

First FAO International Meeting on Dairy Education, Paris, France, 2-8 June 1964 (110 pages, AN-1964/5). E, F, S.

Second FAO International Conference on Dairy Education and Training, Copenhagen, Denmark, 24-31 August 1970 (73 pages, AGA-1970/5). E, F, S.

First Meeting of the FAO Expert Panel on Dairy Education, Rome, Italy, 6-10 September 1965 (20 pages, AN-1965/7). E, F, S.

Second Meeting of the FAO Expert Panel on Dairy Education, Rome, Italy, 28 August-1 September 1967 (22 pages, AN-1967/7). E, F, S.

Third Meeting of the FAO Expert Panel on Dairy Education, Rome, Italy, 1-5 September 1969 (31 pages, AN-1969/8). E, F, S.

Séminaire de la FAO sur l'éducation et la formation laitières dans les pays francophones d'Afrique, Dakar, Sénégal, 3-8 février 1969 (29 pages, AN-1969/1). F.

FAO Seminar on Dairy Education and Training for Countries in Asia and the Far East, Los Baños, Philippines, 18-23 May 1970 (36 pages, AGA-1970/2). E.

Seminar on Dairy Education and Dairy Development in the Near East, Beirut, Lebanon, 4-9 October 1971 (56 pages, AGA-1971/11). E, Ar.

FAO Seminar on Dairy Education and Dairy Development for English-Speaking Countries in Africa, Kampala, Uganda, 17-22 July 1972 (55 pages, FAO/DEN/TF-76, AGA/1972). E.

19th International Dairy Congress

The next Congress of the International Dairy Federation will be held in Delhi, India, in December 1974. The theme is to be: "Dairying as an instrument of economic and social change." Special efforts are being made to attract a larger than usual number of delegates from Africa, Asia and Latin America.

The Government of India has requested the National Dairy Development Board to be responsible for organizing the Congress.

Further details will be published in a future issue of *World Animal Review*.

Animal health yearbook, 1971

FAO, 1972, 205 p., 3 maps, 87 tables. Price: U.S.$4.00, £1.60, FF 20. (Trilingual)

This Yearbook, published annually since 1958 under the joint sponsorship of the Food and Agriculture Organization of the United Nations, the World Health Organization and the International Office of Epizootics, contains information on about 100 animal diseases in nearly all countries of the world, indicating occurrence, species affected and methods of control. Diseases of bees and fish are also covered. Several changes have been introduced in the presentation of the tabulated information, for the convenience of readers and in order to include as much information as possible under a reduced format.

The 1971 Yearbook contains information available to 31 December 1971. Reports from 157 countries on livestock population, human population and numbers of veterinarians are provided in tabulated form. Maps and tables referring to foot-and-mouth disease and vesicular stomatitis are included. The Yearbook is trilingual in English, French and Spanish, with glossaries in German and Russian.

There is a multilingual index which includes synonyms in several languages, names of causal agents, and references to additional, clinically or etiologically related diseases.

Histology

C.J. PRICE and JOSEPHINE E. REED. UNDP/FAO, Rome, 1972. 109 p., 73 figures. Prices: U.S.$0.50 or 20 p. (In English)

This is the sixth and last volume in the series *Notes for Students of Animal Husbandry*. It is written in a clear and simple style, with numerous diagrams in colour and black and white, and is designed especially for students studying agricultural science, and to whom English is probably a second language.

It is important to all students of animal husbandry to study histology, the structure of animal tissue. This is a necessary prerequisite to the understanding of normal and abnormal body processes in general, and it is essential for the identification of cells harbouring parasites. This text emphasizes structure but also shows relations between tissues on the basis of their embryological development.

Animal diseases - their effect on agricultural economics

Les maladies animales — leur incidence sur l'économie agricole. P. MORNET (Editor). Service de Presse, Edition, Information, Paris. 1972. 363 p., numerous figs., tables, and maps. Price: FF 90 (In French)

This book, the first of its type, is a general review of the economic impact of animal diseases on the livestock industry in France. Top specialists have contributed to its preparation: professors of agricultural and veterinary colleges, scientists from the Institut national de la recherche agronomique and veterinary services, agronomists and veterinarians.

The work is divided into two main parts. First, general statistical and economic data on various aspects of the animal industry are given: cattle, sheep, goat, pig, horse, poultry, fur animals, wildlife, fish and bee husbandry is reviewed. In the second part each chapter is devoted to a specific disease, and the economic consequences of this disease are reviewed.

Distinctions are made between direct losses (such as mortality) and indirect losses (resulting from lower production, and from curative and preventive treatments); and secondly, between losses caused by prevalent diseases and losses from others — like foot-and-mouth disease — which are not current but need preventive measures since they form a potential threat to the country.

Although this study has been limited to France, it is nevertheless a very valuable source of information and suggests the animal health officer should think in terms of economics. It also guides him in estimating costs and establishing a health balance. This study will be particularly useful to those who are involved in planning animal disease control programmes in developing countries.

The standing of the authors as well as the interest attached to the subjects make this book, with its many illustrations, an invaluable working document at a time when profit from the livestock industry and related projects is a major concern both for developing countries and international development agencies.

M.L.

Diseases of feedlot cattle

R. JENSEN and D.R. MACKEY. Lea and Febiger, Philadelphia, United States (1971). Second edition; 377 p., 191 figs., 32 tables. Price: U.S. $13.50 (In English)

The general pattern of describing cattle diseases as found in other books is followed, with reference to feedlot cattle, particularly in the United States. No disease conditions exclusive to feedlot cattle are mentioned. Emphasis is given to clinical diagnosis, methods of prevention and treatment of diseases. The chapter on preconditioning cattle for feedlots gives a brief but useful account of the procedures to be followed in handling animals from a nutritional and health point of view on arriving at the feedlot, and another dealing with the problem of pollution from cattle feedlots is considered interesting.

F.N.

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Histology

by C.J. PRICE and J.E. REED

A textbook on the minute structures of the tissues of the animal body. Of great importance to animal health students. $0.50 or £0.20

Milk and milk products in human nutrition

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Contagious bovine pleuropneumonia

by J.R. HUDSON

A detailed study of a disease which is a menace to cattle in a belt across central Africa. $3.00 or £1.20

Animal health yearbook, 1971

An annual world livestock disease report, with tables showing the name of disease and species of animal in which the disease is reported. $4.00 or £1.60

Fifth report of the Joint FAO/WHO Expert Committee in Brucellosis, 1970

The Committee reviews the results of research carried out since its last meeting and strongly urges the adoption of uniform diagnostic standards. $1.25 or £0.40

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